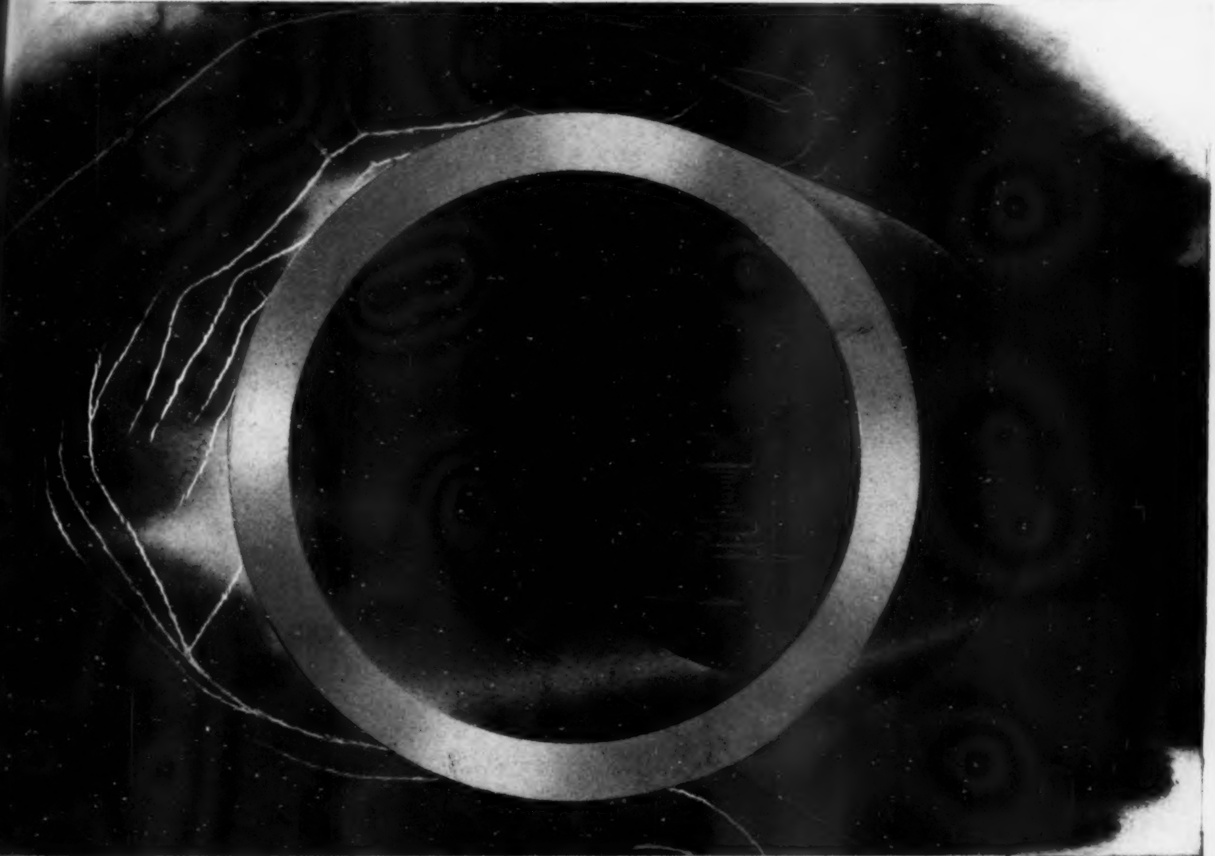
METALLURGIA

THE BRITISH JOURNAL OF METALS

Vol. 46 No. 277 NOVEMBER, 1952 Monthly: TWO SHILLINGS



METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

NOVEMBER, 1952 Vol. XLVI. No. 277

Speed the Exports

At no time since the end of the war has the importance of high productivity been greater than it is to-day. We must import food and raw materials, and in order to pay for them the products of our industries must find a sale abroad, since our overseas investments were largely dissipated in order to maintain the struggle for freedom from 1939 to 1945. The country's natural resources being limited, it follows that our main export is the labour which is put into native and imported raw materials in order to increase their value and that, within limits, the more work put into an export product the better. This situation has existed throughout the post-war era, but there is one important change which has taken place in that time. During the first few years after the war, a sellers' market prevailed, with the result that there was no difficulty in selling as much as we could produce. Now, all that is changed and a " take it or leave it " attitude will no longer meet the case : the salesman is having to develop anew his sales technique.

There are many contributory factors to this change : some of the leeway resulting from the non-productive war years is beginning to be made up ; currency difficulties have resulted in import restrictions in a number of countries ; formerly highly industrialised countries such as Germany and Japan are now presenting a strong challenge in the struggle for export markets. Whatever the cause, it is an indisputable fact that the export trade is once more a highly competitive business in which the orders go to those who can supply for the least cost and in the shortest time. We have repeatedly stressed the importance of quality in our export goods—for quality obtains, and even more certainly retains, custom—but quality cannot achieve much unless it is backed up by quick delivery and reasonable price. A superior article in twelve months time is no use to a man whose need is so urgent that next month will be too late. There is little doubt that we are to-day losing orders because we cannot deliver the goods. A striking example is the ship repairing industry, where there is now a certain amount of unemployment because ship-owners are getting their repairs done in Continental yards where the work is executed more quickly than in Britain. Can they be blamed ? Every day a ship is not at sea, whether it is in the dock or in the repair yard, it is losing money, and the logical outcome of such a situation is a rise in freight charges or bankruptcy. And such cases can be multiplied.

Without doubt, the majority of the workers in this country are better off than they were before the war, in spite of the increased cost of living. But of what use to a man is a Welfare State, a five-day week, two weeks paid holiday and increased pay if they contribute to his losing his job ? The help received from the United States has been exceedingly valuable in tiding over the difficulties of the post-war years—without it, things would have been very grim indeed—but we must be prepared to stand on our own feet. The recent Presidential Election in the United States adds point to this view, for however high our regard for Mr. Eisenhower himself may be, it is likely that his Administration will show itself to be more deflationist, more protectionist and more isolationist than the Truman Administration, and that this may possibly mean less trade and less aid.

Britain emerged from the conflict in 1945 a vastly poorer country than she entered it in 1939, and yet everyone seems to be under the impression that they ought to be better off than they were before the war. How this is to be achieved is not clear—presumably by the simple expedient of " soaking the rich." A little elementary arithmetic should show the absurdity of such a course. The national income is now almost entirely dependent on what we sell abroad, which in turn is going to be governed, more than ever before, by our production costs and profits at home. It follows, therefore, that wage increases given because of a rise in the cost of living, and unaccompanied by a corresponding increase in production, stand condemned equally with excessive profits on products. Both will lead to loss of orders and, ultimately, to national suicide. It must be realised that any increase in our standard of living must be earned, and that the acceptance of lower standards now may be the only way in which we can ensure higher standards in the future.

Sooner or later, all discussions on these lines come up against the problem of increasing productivity as a means of reducing production costs. Anyone who has read a number of the reports which have been made by the productivity teams on their return from the United States must have been struck by the way in which certain factors are emphasized in almost every report. On occasion, instances were found where an American industry was technically ahead of its British counterpart, but on the whole the keys to productivity were seen less in technical achievements than in social attitudes. It was the spirit prevailing in American industry that impressed them more than its physical organisation.

One technical aspect of productivity noted by most, if not all, of the reports is the attention paid to materials handling and servicing the worker. Contrary to popular belief, materials handling is not applicable only to mass production operations ; it is equally suited to the jobbing factory. In this country, the study of the subject has received considerable impetus in the post-war years, and in an attempt to further its application in industry, there has recently been formed an Institute of Materials Handling. This should also direct attention to the importance of a study of the problems involved, and give encouragement to those who are thinking of specialising in this branch of engineering.

City and Guilds of London Institute

Insignia Award in Technology

The City and Guilds of London Institute was established in 1878 by the Corporation and certain of the Livery Companies of the City of London, for the advancement of technical education as an aid to industry. In 1879 the Institute took over from the Royal Society of Arts the small group of examinations in technical and craft subjects which that Body had inaugurated. This effort through the medium of examination to encourage further study by those engaged in industry has been steadily developed and extended by the Institute's Department of Technology in two main directions, namely in the intermediate and other examinations designed primarily for craftsmen and operatives; and in the final and subsequent examinations leading to Full Technological Certificates.

The Institute considers that in certain branches of industry the time has now arrived when additional encouragement and recognition could usefully be given at a higher level than that represented by its Full Technological Certificates to those engaged in industry who continue to pursue their studies and to broaden their knowledge. In furtherance of this objective the Institute proposes to establish under its Royal Charter an *Insignia Award in Technology* which will lay emphasis upon technical training based primarily upon practical experience, supplemented by theoretical study, as distinct from the more academic approach to training for which many educational facilities and inducements already exist. This new Award is intended to be a mark of distinction for those who have combined with a sound practical training an adequate knowledge of the fundamental scientific principles of their industry, and who possess a capacity for leadership and administration.

The institution of this Award has two further objects. In the first place, it will encourage those who have completed a course of training in some branch of industry to extend their studies to its broader problems, and to widen their knowledge of the scientific principles upon which their industry is based. In this way they will become better able to apply new methods to their work and to know when to seek the assistance of those with more advanced and specialised knowledge.

The Institute also believes that the introduction of the Award will encourage students to take full advantage of the facilities provided in industry and technical colleges and will lead to the recognition of the value of practical training and experience as basic requirements.

Having regard to the breadth of knowledge called for, and the other conditions to be fulfilled (see below), the standard of the Insignia Award will be well above that of any existing Full Technological Certificate. The Institute intends to introduce the Award gradually as opportunity offers in the main branches of the chemical*, constructional, electrical, mechanical and textile industries. The co-operation and assistance of representatives of industry will be sought in judging the eligibility of candidates, so that the Insignia Award will be indicative of exceptional competence and will ensure that persons receiving it will be recognised as being both trained and qualified to occupy posts of technical and executive responsibility in the class of work and in the branch of industry specified on the Warrant they will receive.

Conditions of Award

The general conditions governing the award state that a candidate shall:

(*a*) be not less than 30 years of age on the 31st December of the year immediately preceding the date of application;

(*b*) have completed the full period of apprenticeship appropriate to his employment or, where there has been no formal apprenticeship as such, the equivalent period of suitable practical training, as may be approved by the Institute;

(*c*) have obtained the Full Technological Certificate of the City and Guilds of London Institute in an appropriate branch of technology, supported by passes in suitable ancillary subjects. For an interim period, however, candidates may be accepted for consideration if they have gained an approved group of qualifications awarded by the Institute;

(*d*) have had at least seven years suitable industrial experience subsequent to completion of apprenticeship or equivalent training;

(*e*) have attained a level of general education satisfactory to the Institute;

(*f*) show that he has continued to study the practice of his particular branch of industry during the period of his industrial experience;

(*g*) submit the names of three suitably qualified referees to whom he is known;

(*h*) satisfy the Institute that he possesses the requisite qualities for the exercise of practical responsibility in his field of employment;

(*i*) show evidence of a critical appreciation of problems of his branch of industry and of his general capacity and ability by the submission of a report or thesis on a subject specified by the Institute after consideration of a list submitted by the candidate.

Apart from the candidates' qualifications in terms of a record of his experience and of the certificates he has gained, the main tests for the Award of the Insignia are the preparation and submission of a thesis or report and the subsequent interview by a Panel of the Insignia Award Committee.

Candidates are given the opportunity of suggesting three or four subjects for the proposed thesis and the Committee acting through their expert advisers will accept one of these if it is deemed suitable. Alternatively, however, they reserve the right to substitute a subject or topic outside the range offered by the applicant.

The final stage in the sequence of the Institute's consideration of the candidates' application is the interview, and considerable weight is accordingly given to it. He should expect to be questioned closely on any matter relating to his education, training and career, and on the specific topic of his thesis and any points arising therefrom.

Copies of the General Regulations governing the Insignia Award scheme, together with Notes for the Guidance of Candidates and an Application Form for the Registration of Candidates, will be sent on receipt of a stamped addressed envelope. Enquiries should be addressed to The Director, Department of Technology (I.A.), 31, Brechin Place, South Kensington, London, S.W.7.

* Metallurgical industries are included in the chemical group.

The Properties of Some Binary Aluminium Alloys at Elevated Temperatures

By J. V. Lyons*, Ph.D., and W. I. Pumphrey†, M.Sc., Ph.D.

In order to obtain some knowledge of the factors which affect the mechanical properties of aluminium alloys at temperatures both above and below the solidus, and which, therefore, affect their welding and casting properties, the high temperature tensile properties of the binary alloys of aluminium with copper, iron, manganese and zinc have been determined. An examination has also been made of the effect of the degree of approach to structural equilibrium on the high-temperature properties of certain of the alloys tested. This work is published in two parts ; the experimental results obtained are presented here, and their significance will be discussed in the second part to be published in our next issue.

1. Introduction

In an attempt to ascertain the reasons for the cracking which occurs in certain aluminium alloys during casting and welding, Singer and Cottrell[1] carried out tensile tests at elevated temperatures on a number of aluminium-silicon alloys of commercial purity. On the basis of the results so obtained they suggested that there is a relationship between the constitution of aluminium alloys, their mechanical properties at temperatures between liquidus and solidus, and their observed tendency to crack when welded or cast under conditions of restraint[2]. The high temperature tensile tests carried out by Singer and Cottrell were, however, made on alloys which were in a state of structural equilibrium at the moment of testing ; and the theoretical suggestions based on the results of their tests may not be directly applicable to casting and welding since, in such operations, the cast metal or deposited weld metal is far from being in a state of structural equilibrium during solidification and subsequent cooling. The present work was therefore undertaken, first, to examine the effect of the degree of structural metastability on the mechanical properties at elevated temperatures of the more common binary aluminium alloys ; and secondly, to determine to what degree the results so obtained could be correlated with the results of previous casting and welding tests[3] on the alloys.

In the present work, alloys in the four binary alloy systems aluminium-copper, aluminium-iron, aluminium-manganese and aluminium-zinc were selected for examination. It was thought that these alloys would be in a structurally metastable condition when cast, and that their rate of approach to structural equilibrium would be so slow during reheating that it would be possible to reheat the alloys, for the purpose of tensile testing at high temperatures, without materially affecting their cast structure. It was also expected that it would be possible to examine the effect of the degree of approach to structural equilibrium on the mechanical properties of the alloys at high temperatures by homogenising the alloys for varying periods before testing.

Pumphrey and Lyons[3] found that the tendency to cracking, during casting and welding, of alloys in the systems aluminium-copper, aluminium-manganese and aluminium-zinc was not in complete accordance with theoretical predictions based on the results obtained by Singer and Cottrell, and it was hoped that the results obtained in the present investigation would provide some indication of the reasons for the difference between the theoretical predictions and the experimental results obtained with the alloys in these systems.

2. Previous Work

The majority of the investigations into the problem of hot shortness or cracking have consisted of attempts to classify alloys into various categories by means of some form of casting test to assess their tendency to hot-shortness. Such methods provide little indication of the precise mechanism of hot-shortness or cracking, or of the relationship between the tendency to cracking and the structure of the alloy, and it would seem that a determination of the actual mechanical properties of alloys at elevated temperatures is necessary to provide information upon which to base a theoretical explanation of the phenomenon.

An account of the work previously undertaken in this field is contained in the paper by Singer and Cottrell[1]. These latter workers determined the mechanical properties of aluminium-silicon alloys at elevated temperatures and related the results to the hot-shortness of the alloys concerned. Test-pieces machined from cast bars of a series of aluminium-silicon alloys (based upon commercial-purity aluminium) were tested in a horizontal Tensometer. The alloys were found to elongate appreciably up to the solidus temperature, beyond which temperature all ductility was lost. The strength, which was observed to decrease rather gradually with increase in temperature, also fell suddenly to a small, but finite value at the solidus, and a certain strength was retained up to some temperature between solidus and liquidus. A theory was proposed, and later expanded by Singer and Jennings[2], relating the hot-shortness of aluminium-silicon alloys, as determined in casting and welding tests, with the brittle temperature range existing above the solidus. This theory is discussed more fully later.

3. Experimental Work

3. 1. Preparation of the Alloys

All the alloys were prepared from aluminium of 99·988% purity and the appropriate high-purity temper alloy or virgin metal. In the four alloy systems investigated, the choice of suitable alloys for examination was based upon data from an earlier investigation of the

* Research Metallurgist, Department of Development and Research, Tube Investments, Ltd., Birmingham.
† Research Manager, Murex Welding Processes Limited.

TABLE I.—CHEMICAL ANALYSIS OF ALUMINIUM-COPPER ALLOYS.

Nominal Composition Copper %	Actual Composition Determined by Chemical Analysis.	
	Copper %	Other Elements
0·5	0·55	Chemical analysis for iron and manganese indicated that the alloys contained less than 0·01% of each of these elements. Spectrographic analysis indicated that no measurable quantities of impurities, other than iron and manganese, were present.
1·0	1·06	
2·0	1·90	
3·0	3·07	
4·0	3·80	
6·0	5·84	
10·0	9·90	
15·0	15·55	

tendencies of the alloys to crack during casting and welding.

A number of bars, ¾ in. in diameter and 10 in. long were cast in each alloy. A macro-examination was made of each cast bar to ensure that the crystal size was identical in the several bars of each alloy.

Chemical analysis was carried out on a representative bar of each alloy and the compositions determined in this way were found to be little different from the nominal compositions. This is shown by the results for a series of aluminium-copper alloys recorded in Table I. These results are typical of those obtained with the alloys in the other three systems examined.

3. 2. Homogenising Procedure

In order to study the effect of the degree of approach to structural equilibrium on the mechanical properties at elevated temperatures, all the aluminium-copper alloys were tested in the cast condition and also after homogenising for a period of 72 hours at temperatures some 20° C. below their solidus temperatures. The aluminium-copper alloys containing 2%, 4%, 6% and 10% of copper were also tested after being homogenised at a temperature of 535° C. for 32 days.

The aluminium-iron and aluminium-manganese alloys were tested in the cast condition and also after homogenising at a temperature of 620° C., the aluminium-iron alloys being maintained at this temperature for 28 days and the aluminium-manganese alloys for 42 days before testing.

The aluminium-zinc alloys were tested in the cast condition only.

3. 3. Mechanical Testing

The apparatus used in the present investigation for high temperature tensile testing was identical in all essentials with that used by Singer and Cottrell[1]. The tensile tests were carried out on a Hounsfield Tensometer fitted with a motor drive, and the specimens were maintained at the required temperature during testing by means of a resistance tube furnace arranged to slide along the horizontal tie-bars of the Tensometer.

The design of the test-piece used for testing at temperatures at which the alloys retained some ductility —that is, at temperatures up to and slightly above the solidus—is shown in Fig. 1. For testing at temperatures at which there was a continuous film of liquid around the individual crystals of the alloys, that is, at temperatures somewhat above the solidus, a test-piece was used which was totally enclosed by the specimen grips. In all the tests the specimen was heated to the temperature of testing in about 20 minutes and maintained at that temperature for a further five minutes before being extended to fracture. For further details of the testing procedure at temperatures above and below the solidus, reference should be made to the original paper by Singer and Cottrell[1].

4. Experimental Results

Graphical representations of the variation of strength with temperature for certain typical alloys are included in the appropriate sections of this paper.

4. 1. Aluminium-Copper Alloys

(a) Results obtained in the Tensile Tests.

The ultimate tensile strength of all the aluminium-copper alloys, whether tested in the cast or in the homogenised condition, was observed to decrease continuously with increase in the temperature of testing, although the decrease in strength was more rapid the higher the copper content.

With those alloys containing 4% or less of copper, the strength fell with increasing temperature, at first rapidly and then more slowly as the effective solidus temperature was approached. The onset of melting at the crystal boundaries caused no sudden decrease in strength, but with increase in the amount of liquid in the test-piece the fall became more rapid. With those alloys containing appreciable quantities of copper, the strength decreased suddenly with the onset of melting. A brittle fracture was obtained with all the alloys tested at temperatures a few degrees above the temperature of incipient melting, but all the alloys retained a certain degree of coherence up to a temperature between solidus and liquidus at which so much liquid was present in the mass that all coherence and strength were lost. This is illustrated by the curves in Figs. 2 and 3 which show the variation of strength with temperature for an aluminium-copper alloy containing 4% of copper.

The elongations and reductions of area given by the specimens were adversely affected by slight casting defects, such as porosity, even when the tensile strength itself was not seriously impaired, and it was found impossible to establish any significant relationship between elongation, or reduction of area, and the temperature of testing. For this reason it was decided that the appearance of the fracture was a more certain guide to the ductility of an alloy than the values obtained for elongation and reduction of area. In Fig. 2 some indication is given of the temperature ranges over which certain well-defined types of fracture were obtained. At temperatures of testing below that at which melting began, the specimens, in general, elongated considerably before final fracture. Specimens in which such elongation did occur before final fracture have been classified as giving a " normal " fracture. The first appearance of liquid in the specimens caused cracks to occur in the gauge length, during testing, even at points remote from the final fracture, while the elongation and reduction of area decreased to approximately

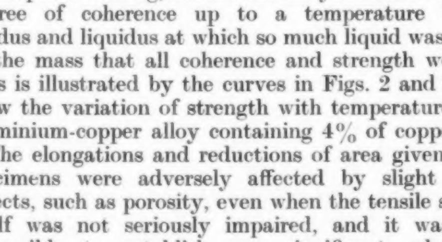


Fig. 1.—Test-piece for testing at temperatures up to and slightly above the solidus.

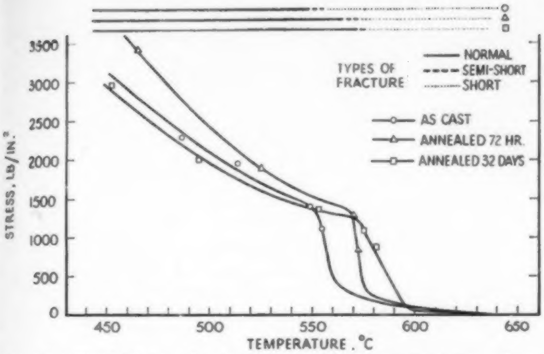


Fig. 2.—Variation of strength with temperature of an aluminium-4% copper alloy.

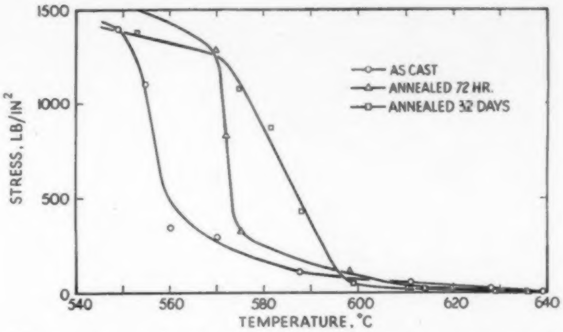


Fig. 3.—Strength of an aluminium-4% copper alloy in the region of the solidus.

The word annealed in Figs. 2, 3 and 8 should be taken to indicate that the material has been homogenised for the times stated.

50%. Specimens in which fracture occurred in this way have been reported as giving "semi-short" fractures. The brittle fractures, unaccompanied by any elongation or reduction of area, which were obtained at the higher temperatures of testing are described as "short" fractures.

The strength of those aluminium-copper alloys, such as the alloys containing 6%, 10% and 15% of copper, which contained appreciable quantities of eutectic, decreased in the normal manner with increase in the temperature of testing, up to the effective solidus temperature or the temperature of incipient melting. At this temperature, however, the considerable amount of eutectic present in these alloys melted suddenly and the strength/temperature curve fell very rapidly to zero, no strength being retained by the alloys over any extended range of temperature above the solidus.

(b) Effect of the Degree of Approach to Structural Equilibrium on the Tensile Properties.

Although the general form of the strength/temperature curve of an alloy is not appreciably affected by the period for which the alloy is homogenised before testing, the strength of the alloy at any one temperature—and the temperatures at which inflections occur in the strength/temperature curve — are, to some extent, dependent on the prior homogenising treatment to which the alloy has been subjected. This is illustrated by the curves in Figs. 2 and 3, which are typical of the curves obtained with all the aluminium-copper alloys containing less than 4% of copper.

With the majority of the aluminium-copper alloys examined, the strength of the cast material is increased at the lower temperatures of testing by the shorter of the two periods of homogenising used. This effect is most marked in those alloys near the maximum equilibrium solid solubility of copper in aluminium, and is probably due to the fact that the copper, which is concentrated at the grain boundaries in the cast alloys, is taken into solution during the homogenising treatment and consequently produces an increase in the strength of the crystals.

In alloys of high copper content, however, the effect of homogenising is reversed, and the alloy containing 15% of copper shows a decrease in strength after homogenising for 72 hours. A possible explanation for such an occurrence in an alloy containing a considerable quantity of eutectic, is that the effective amount of solid solution matrix is increased due to the fact that the α constituent of the eutectic amalgamates with the primary α grains leaving the $CuAl_2$ in the form of globules which are then smaller than the volume of eutectic which existed previously. Hence, after a homogenising treatment, the alloy as a whole is more easily deformed and, therefore, is weaker.

The effect of homogenising for 32 days appears to be rather varied in that it produces no consistent increase in strength such as the shorter treatment is found to do. In considering these results, however, it should be appreciated that homogenising for a long period is conducive to the development of uneven grain size in the homogenised alloys and this, in time, may lead to an irregularity in the mechanical properties.

In all aluminium-copper alloys containing less than the equilibrium solid solubility limit of copper in aluminium, homogenising treatments raise the temperature of incipient fusion, as indicated by the type of fracture. The effect of this is to move the strength/temperature curves of all the alloys progressively to the right, along the temperature axis, the longer the alloys are homogenised before testing. The temperature at which all coherence is lost, however, is not always raised by increase in the time of homogenising before testing—possibly because this temperature is affected by the changes in crystal size brought about by homogenising.

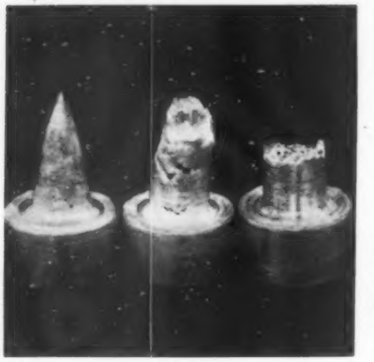
(c) Examination of the Surfaces of Fracture.

As already mentioned, it was found convenient to classify the fractured test-pieces into three main groups according to the appearance of the fractures. The characteristics of each group were described earlier.

Many of the specimens tested at temperatures below the solidus elongated by 100% or more and necked down almost to a point before breaking. This effect, however, was especially characteristic of the alloys of low copper content. In the alloys of higher copper content, fractures of a similar type at temperatures below the solidus were generally accompanied by lower values of percentage elongation.

The second class of fractures occurred in those specimens which had been affected by incipient fusion. In these specimens, cracks formed in the gauge length while the specimen was elongating and an intercrystalline fracture in which the grains were broken away in an irregular manner ensued. The typical appearance of such a fracture is shown in Fig. 4b. A ductile fracture is shown in Fig. 4a and a short fracture in Fig. 4c.

It will, of course, be appreciated that fractures of this type were not observed in alloys of composition beyond


(a) "Normal" fracture having a good elongation.
(b) "Semi-short" fracture.
(c) "Short" fracture

(a) (b) (c)

Fig. 4.—Types of fracture occurring in aluminium-copper alloy test-pieces. Actual size.

the maximum solid solubility of copper in aluminium, that is, in those alloys containing 6%, 10% and 15% of copper. In these alloys, which contain appreciable quantities of eutectic, a sufficient amount of liquid to cause a continuous boundary film, and, consequently, a short intercrystalline fracture, appears at the grain boundaries immediately the solidus temperature is attained.

The majority of examples of the completely short or brittle type of fracture were provided by screw-test pieces and varied somewhat in their appearance. At the lower end of the temperature range in which such fractures occur, no large quantities of liquid are present and the fractures, in consequence, have a "dry" appearance. With increase in the temperature of testing the appearance of the fracture changes and the fracture surface becomes increasingly shiny until, at the point at which all coherence is lost, so much liquid is present and the grains have melted to such an extent that the crystalline appearance of the fracture is no longer evident.

(*d*) *Macroscopic Examination.*

The macrostructures of the cast bars of the aluminium-copper alloys varied from the completely columnar to the completely equiaxed, with increase in the copper content. After homogenising for 72 hours the structures were somewhat refined, the columnar crystals tending towards a more equiaxed habit whilst the alloys of higher copper content exhibited a reduction in crystal size. All the four alloys which were homogenised for 32 days developed an equiaxed structure which became progressively finer with increase in the copper content.

It was apparent from the appearance of sections of the test-pieces, and also of the intercrystalline fractures, that no appreciable change in the macrostructures took place during the heating cycle before testing.

(*e*) *Microscopic Examination.*

In the as-cast condition the structure of all the aluminium-copper alloys was heavily cored and the alloys were far from being in a state of structural equilibrium. No second phase was observed in the structure of the cast alloy containing 0·5% of copper. Small pools or globules of $CuAl_2$ were present in the alloy containing 1% of copper, but the normal Al-$CuAl_2$ eutectic was only found in those cast alloys containing 3% or more of copper. Pronounced inverse segregation was found in the cast bars of the aluminium-copper alloy containing 4% of copper and was also found to some slight extent in the bars of the alloy containing 3% of copper. With the alloy containing 4% of copper, a few crystals at the centres of the bars appeared to contain approximately the same amount of second phase as that found in the alloy containing 3% of copper, whilst the amount of eutectic in the outer regions of the bars was considerably greater than the average for the alloy. Thus a few of the crystals at the centre of a bar of the alloy containing 4% of copper had a structure similar to that shown in Fig. 5, and the structure in the outer regions of the same bar was similar to that shown in Fig. 6. The degree of inverse segregation across the section of the gauge length of a test-piece was, of course, somewhat less than that across the section of a cast bar.

It should be mentioned here that although casting methods are available to combat inverse segregation, no use was made of them in the present investigation. The object of the investigation was to determine the influence of such effects as inverse segregation on the mechanical properties of alloys at elevated temperatures; consequently, it was not desired to prevent their occurrence.

A microscopic examination of the cast alloys which had been homogenised before testing for 72 hours at temperatures some 20° C. below their solidus temperatures, appeared to indicate that the alloys were in a state of structural equilibrium after this treatment. The results obtained in the tensile tests, however, would seem to indicate that complete structural equilibrium had not been attained in the 72 hours, since incipient fusion occurred in the alloys of lower copper content at temperatures considerably below the equilibrium solidus temperatures. This could, perhaps, be ascribed to the

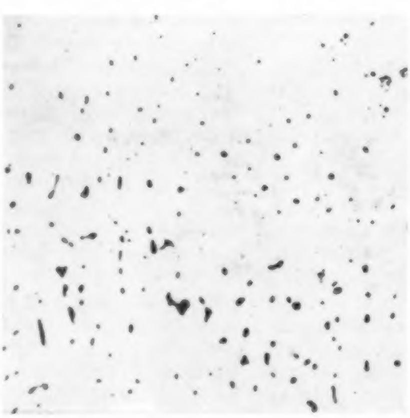


Fig. 5.—Microstructure at the centre of a cast bar of an aluminium-4% copper alloy. Etched in 25% HNO_3 at 70° C. × 150

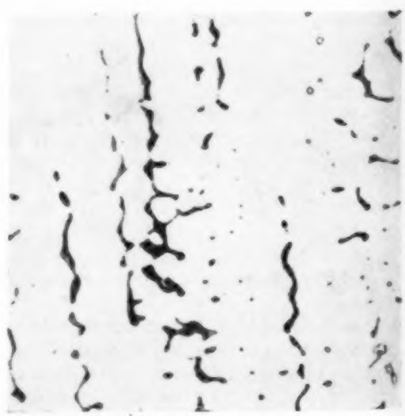


Fig. 6.—Microstructure of a cast bar of an aluminium-4% copper alloy at a point nearer the surface. Etched in 25% HNO_3 at 70° C. × 150

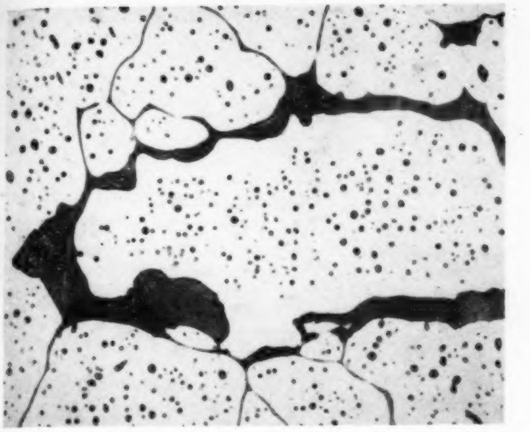


Fig. 7.—Microstructure of an aluminium-10% copper alloy test-piece after testing at a temperature at which the strength has decreased to zero. Etched in 25% HNO_3 at 70° C. × 150

presence of copper-rich regions near to the crystal boundaries, although the occurrence of such regions was undetectable under the microscope.

There was no apparent difference between the microstructures of the aluminium-copper alloys homogenised for 72 hours and those homogenised for 32 days, except that with the longer homogenising time there was some spheroidisation of the $CuAl_2$ in the alloys of higher copper content.

A microexamination of a number of test-pieces showed that even during the short heating cycle before testing, those alloys containing 3% of copper or less had proceeded so rapidly towards structural equilibrium that they contained no eutectic. This was not so, however, with the 4% copper alloy, as was evident from the occurrence of incipient fusion in a test-piece of this alloy pulled at the eutectic temperature. In the alloys containing 6% or more of copper, the $CuAl_2$ was found to have agglomerated to a considerable extent at testing temperatures some degrees below the eutectic temperature.

The results obtained in the tensile tests indicate that with alloys containing 6% or more of copper, melting begins in the crystal boundaries at a temperature lower than the equilibrium eutectic temperature. From the results obtained in previous investigations[4] and the results of a microscopic examination made during the course of the present work, it would seem that the occurrence of melting in the crystal boundaries of aluminium and its alloys at a temperature lower than that at which melting begins in the body of the crystals is not due to the accumulation of impurities at the crystal boundaries but is due, rather, to the physical nature of the boundaries.

Those aluminium-copper alloys which contained eutectic did, of course, provide microscopic evidence of fusion after testing at temperatures above the eutectic temperature of 548° C. Fig. 7 illustrates the structure of a test-piece in which there is a considerable amount of coarse eutectic which has solidified after the completion of the tensile test. This example shows clearly that the liquid present in an alloy at the temperature at which coherence has fallen to zero allows movement of the crystals and flows between the crystals as they are torn apart. In this particular instance, of course, the test-piece was extended until fracture occurred and, therefore, gaps are visible where the eutectic has flowed away to such an extent as to leave voids. Thermal contraction during solidification, however, represents a much smaller extension, so that the formation of fissures is minimised during the solidification of a casting by movement of the crystals and by intergranular flow of the eutectic in the manner illustrated in Fig. 7.

4. 2. Aluminium-Iron Alloy

(a) Results obtained in the Tensile Tests.

The manner in which the strength of the three aluminium-iron alloys varied with the temperature of testing is illustrated by the curves reproduced in Fig. 8 which were obtained with the alloy containing 1% of iron. The general form of the strength/temperature curves for all the aluminium-iron alloys was very similar to that for the aluminium-copper alloys, except that a completely short intercrystalline fracture, accompanied by a sudden fall in strength, occurred at the temperature of incipient fusion.

The tests carried out on homogenised specimens showed that a marked decrease in strength had been brought about by the homogenising treatment, the values of maximum stress at all temperatures below the solidus being reduced by at least 30% after homogenising for 28 days at 620° C. The temperature at which the sudden fall in strength occurred, however, was little affected by the homogenising treatment, and in all three alloys was only about 1° C. higher than the corresponding temperature for the alloys tested in the cast condition. The temperature at which all strength was lost, likewise, was little altered by homogenising.

The reason for the lower strength of the homogenised specimens at temperatures below the solidus, may be the change in the microstructure brought about by the homogenising treatment. The volume of eutectic in the cast alloys is greater than the volume of $FeAl_3$ needles in the same alloys in the homogenised condition. This can be seen in Figs. 9 to 12, which show the effect of homogenising upon the microstructures of alloys containing 0·5% and 1·7% of iron. In the homogenised alloys there are larger areas of solid solution which lack the strengthening effect of the intermetallic dispersion, and hence have a maximum strength lower than that observed with those alloys tested in the cast condition.

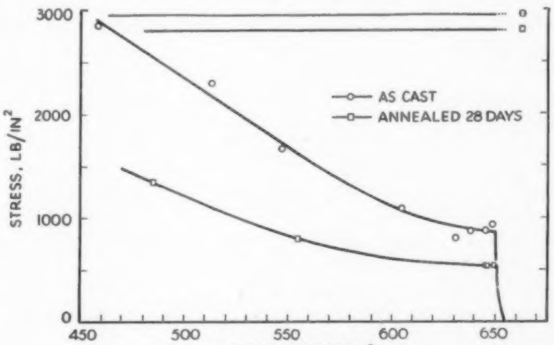


Fig. 8.—Variation of strength with temperature of an aluminium-1% iron alloy.

Fig. 9

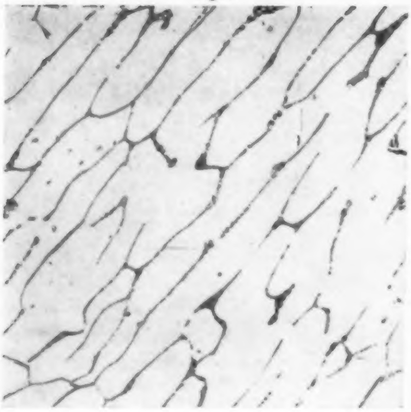


Fig. 10

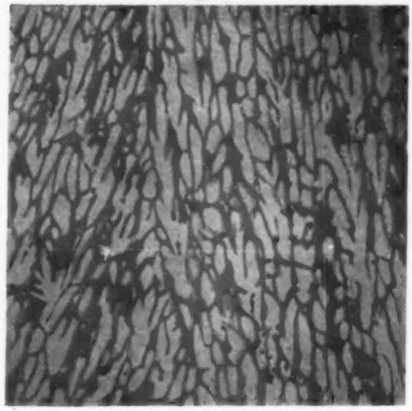


Fig. 11

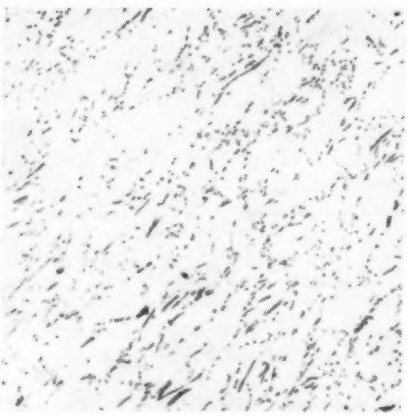


Fig. 12

Fig. 9.—Microstructure of an alloy containing 0·5% of iron. As-cast.

Fig. 10.—Microstructure of an alloy containing 1·7% of iron. As-cast.

Fig. 11.—Microstructure of an alloy containing 0·5% of iron. After homogenising for 28 days.

Fig. 12.—Microstructure of an alloy containing 1·7% of iron. After homogenising for 28 days.

All etched in 0·5% HF (aqueous solution). × 150

All three aluminium-iron alloys contained some quantity of a second phase ; therefore, in all the alloys incipient fusion would have been expected to occur at the same temperature, that is at the temperature of melting of the Al-$FeAl_3$ eutectic. As with the aluminium-copper alloys, however, incipient fusion, manifested by the appearance of " short " or brittle fractures in the test-pieces, occurred at a temperature some 4° C. below the generally accepted eutectic temperature.

The fractures given by the aluminium-iron alloys were either ductile or completely brittle and, as will be clear from the form of the curve in Fig. 8, no intermediate or " semi-short " fractures, such as were obtained with the aluminium-copper alloys, were obtained with the aluminium-iron alloys.

(*b*) *Macroscopic Examination.*

In the cast condition all the aluminium-iron alloys had a completely columnar structure which was so little affected by the homogenising treatment that a columnar formation still persisted after homogenising, despite some slight growth of certain crystals.

(*c*) *Microscopic Examination.*

The structures of aluminium-iron alloys in the cast condition are very different from those of the same alloys when in a condition of structural equilibrium. Thus, the aluminium-iron alloy containing 1·7% of iron, which is the eutectic alloy in equilibrium conditions, contains only 40–50% of eutectic when in the cast condition. This effect was noticed previously by Fuss[5] and by Pumphrey and Lyons[3].

Even during the short time of heating to the temperature of testing, there was some agglomeration of the $FeAl_3$ of the eutectic in the cast alloys, although the general form and mode of dispersion of the $FeAl_3$ particles was not appreciably altered by the brief heating cycle. After homogenising, the $FeAl_3$ assumed a needle-like form, the short needles being evenly dispersed throughout the matrix and having an orientation similar to that of the original dendrites.

As already mentioned, incipient melting of the crystal boundaries, manifested by the appearance of shiny, brittle fractures, occurred at a temperature of 650° C. in the alloys tested in the cast condition, and at 651° C. in the alloys tested after being homogenised for 28 days. The generally accepted temperature of melting of the Al-$FeAl_3$ eutectic is 655° C., and tests confirmed that the observation of melting in the crystal boundaries at a temperature lower than the generally accepted eutectic temperature was not due to any imperfections in the method of temperature measurement. As with the aluminium-copper alloys, microscopic examination failed to reveal the presence of any large areas of chilled liquid or of accumulations of impurities at the crystal boundaries ; as already mentioned, it is believed that the occurrence of melting in the crystal boundaries at a temperature below that at which melting begins in the body of the crystals is due to the physical nature of the boundaries, and in particular to the high strain-energy in such regions.

4. 3. Aluminium-Manganese Alloys

(*a*) *Results obtained in the Tensile Tests.*

The strengths of all the aluminium-manganese alloys decreased in a roughly linear manner with increasing temperature when the alloys were tested in the cast and in the homogenised conditions. At the lower

temperatures of testing, however, the strengths of the alloys tested after homogenisation were some 25% lower than those of the same alloys heated to the temperature of testing from the cast condition.

At the temperature of incipient fusion a sudden fall in strength occurred with all the alloys. The temperature of incipient fusion was somewhat higher for the homogenised alloys than for the alloys tested in the cast state. All the alloys, in both conditions, retained some measure of strength at temperatures above the temperature of incipient melting; at a temperature of 659° C., however, the alloys lost all coherence.

(a) 3% Mn. (b) 5% Mn.

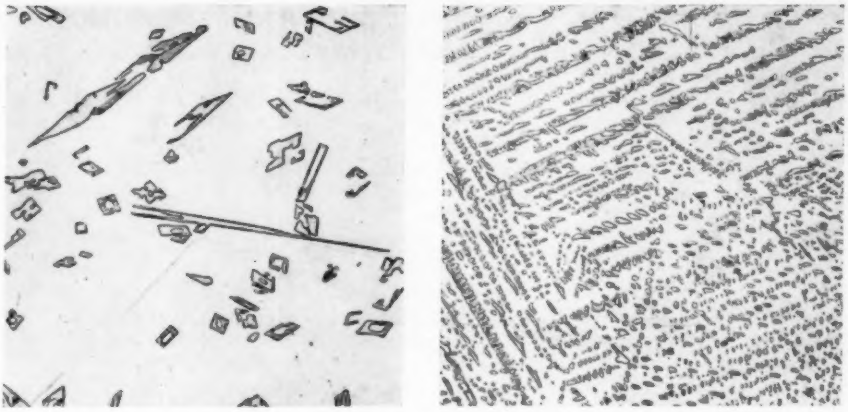
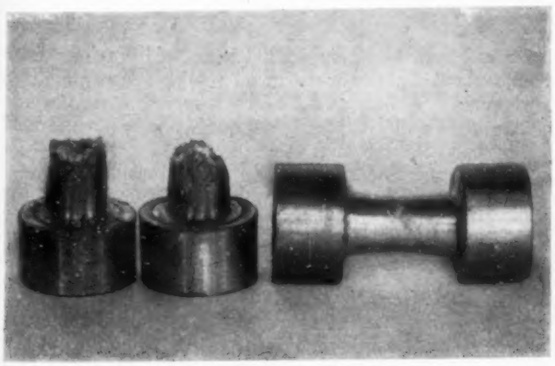


Fig. 14.—Microstructure of aluminium-manganese alloys in the cast condition. Etched in 0·5% HF (aqueous). × 100

(b) *Examination of the Surfaces of Fracture.*

It was found that, even at temperatures below the effective solidus temperature, or, the temperature of incipient melting, the ductility of all the aluminium-manganese alloys was somewhat low in comparison with that of alloys of similar alloy content in the aluminium-copper, aluminium-iron and aluminium-zinc systems. The fractures in all the aluminium-manganese alloys tested at temperatures below the effective solidus temperature appeared to be intercrystalline in nature. The appearance of a typical fracture of this type, obtained with an aluminium-manganese alloy containing 2% of manganese tested at a temperature of 599° C., is shown in Fig. 13a.

The appearance of all the fractured specimens of the aluminium-manganese alloys suggested that cracking had occurred in the gauge length during the initial stages of deformation. By partially extending specimens and removing them from the Tensometer before complete fracture occurred, it was found that cracking had, in fact, occurred in this way. The appearance of the test-piece shown in Fig. 13b which was extended by about 10% before being removed from the Tensometer, is illustrative of this effect.



(a) (b)

Fig. 13.—Aluminium manganese alloy test pieces: (a) aluminium-2% manganese alloy completely fractured at a temperature of 599° C.—intercystalline type of fracture; (b) aluminium-3% manganese alloy extended 10% at 593° C. and then removed from the Tensometer.

(c) *Macroscopic Examination.*

The structure of all the cast aluminium-manganese alloys was columnar. After homogenising for a period of six weeks the crystal structure became equiaxed in the alloys containing 0·5% and 1·0% of manganese, but the columnar structure of the cast alloys remained after homogenising in the alloys of higher manganese content. This is probably because the presence of $MnAl_6$ in considerable quantities in the alloys of higher manganese content impeded grain growth.

(d) *Microscopic Examination.*

A survey of the micro-structures of the aluminium-manganese alloys revealed that the alloys containing 2% or less of manganese consisted almost entirely of solid solution when in the cast condition, but contained some $MnAl_6$ at the crystal boundaries. In those alloys containing 3% and 5% of manganese, the amount of $MnAl_6$ at the crystal boundaries was much greater, and in these alloys the $MnAl_6$ occurred in a more massive form, as shown in Figs. 14a and 14b.

After homogenising, more $MnAl_6$ appeared in the structures of the alloys of lower manganese content. Figs. 15a and 15b show $MnAl_6$ present at the grain boundaries and within the grains of aluminium-manganese alloys containing 1% and 2% of manganese. There was a change in the distribution of the second phase in the alloys containing 3% and 5% of manganese, after homogenising, as shown in Figs. 15c and 15d.

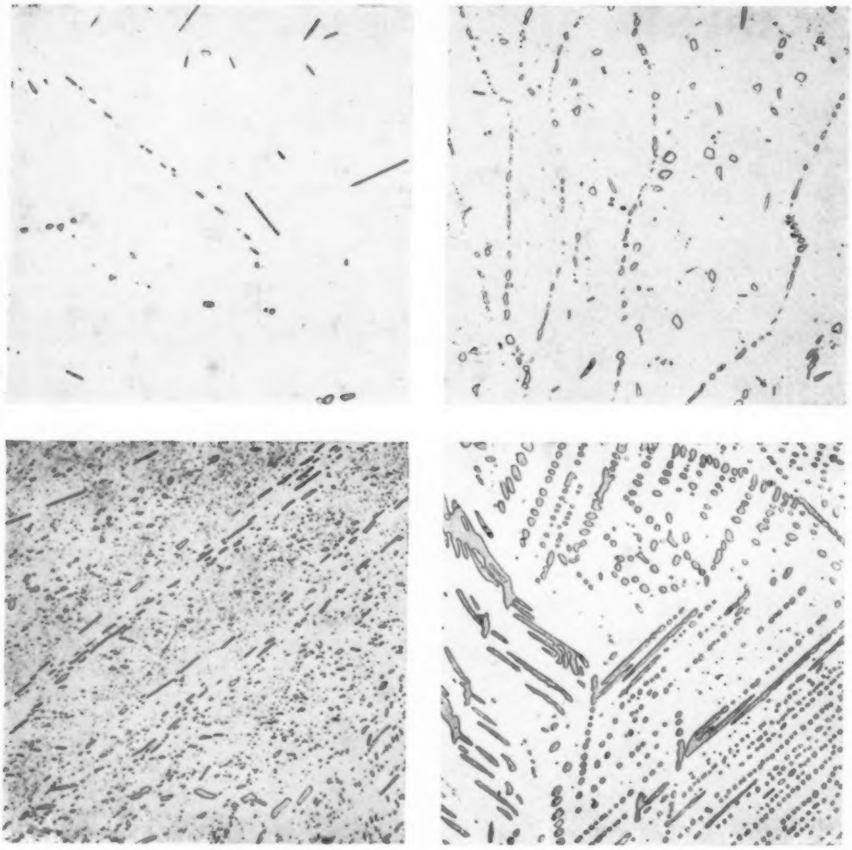
4. 4. Aluminium-Zinc Alloys

(a) *Results obtained in the Tensile Tests.*

The form of the strength/temperature curves and the types of fracture encountered during the testing of the aluminium-zinc alloys were similar in all respects to those obtained with the aluminium-copper alloys of low copper content.

No tests were carried out on aluminium-zinc alloys homogenised before testing since, from the results of previous work, it was anticipated that effects such as coring and variations in crystal size due to casting would be of major importance in determining the tensile properties of aluminium-zinc alloys at elevated temperatures.

(a) 1% Mn. (b) 2% Mn.



(c) 3% Mn. (d) 5% Mn

Fig. 15.—Microstructure of aluminium-manganese alloys after homogenising. Etched in 0·5% HF (aqueous). × 100

A few bars of two aluminium-zinc alloys containing 16% and 20% of zinc were cast into chilled moulds in order to obtain bars having a fine crystal size for comparison of the tensile properties of such bars with those of bars of larger crystal size. The results obtained with specimens of small crystal size were very similar to those obtained with specimens of larger crystal size.

(*b*) *Macroscopic Examination.*

The structure of all the cast aluminium-zinc alloys containing up to 14% of zinc was columnar. With the alloys containing 16% and 20% of zinc, an equiaxed structure with an average grain diameter of about 2 mm. occurred in the bars cast by the normal procedure. The bars of those alloys which were cast with the intention of producing a fine macro-structure had an equiaxed grain structure in which the average grain diameter was about 0·3 mm.

(*c*) *Microscopic Examination.*

All the aluminium-zinc alloys consisted entirely of α solid solution, although the solid solution was heavily cored and there were areas rich in zinc between the dendrite arms.

REFERENCES.

1 A. R. E. Singer and S. A. Cottrell. *J. Inst. Metals*, 1946, **73**, 33.
2 A. R. E. Singer and P. H. Jennings. *J. Inst. Metals*, 1946, **73**, 197.
3 W. I. Pumphrey and J. V. Lyons. *J. Inst. Metals*, 1948, **74**, 439.
4 W. I. Pumphrey and J. V. Lyons. *Nature*, 1949, **163**, 960.
5 V. Fuss. "Metallography of Aluminium and its Alloys," Chapman & Hall, London, 1936, 94.
6 W. I. Pumphrey and P. H. Jennings. *J. Inst. Metals*, 1948, **75**, 203.
7 W. I. Pumphrey and P. H. Jennings. *J. Inst. Metals*, 1948, **75**, 235.

Heenan and Froude Test Plant for British Timken

MESSRS. BRITISH TIMKEN LIMITED are now installing a Heenan and Froude rear axle test plant, adapted for carrying out "life" tests on Timken bearings. This will be followed by another plant (specially designed by Heenan and Froude Limited) for "deflection" tests as part of the general policy of Messrs. British Timken Ltd. to equip a new Research Department for testing bearings.

The "life" test plant is intended for testing the rear axles of cars, lorries, etc. fitted with Timken bearings, under conditions of acceleration, over-run and deceleration, according to speed/load cycles which can be modified at will. The plant is driven by a 35 B.H.P. motor, through two Heenan–Dynamatic eddy-current couplings, one acting as a speed-varying drive and the other as a variable brake, control being through load-presetting devices and push-buttons. The maximum propeller-shaft speed is 4,000 r.p.m. Alterations from the standard design consist of means for accommodating a wider range than usual of rear-axle dimensions and offsets of propeller-shafts. Although primarily intended in this case for research, the plant is also suitable for rapid check-testing of axles on a production basis.

The "deflection" testing plant, as its name implies, is being installed to permit the measurement of the deflection of bearings under load, while actually working.

Secondary Light Metal Prices

THE Federation of Secondary Light Metal Smelters announces that as from Monday, 3rd November, 1952, the maximum selling prices of the undermentioned alloys is as follows :—

L.M.1	£158 per ton
L.M.2	£175 per ton
L.M.4	£164 per ton
L.M.6	£194 per ton

Handling—The New Technology

The first paper to be presented to the recently formed Institute of Materials Handling was read by Mr. L. Landon Goodman, Electrical Development Association industrial specialist, on October 24th, 1952. After discussing the scope of materials handling in industry, the author went on to outline the means whereby more widespread application of its methods could be achieved, and to consider the facilities for education and training. A slightly abridged version of the paper is presented here.

THE handling of material has been with us since the dawn of time. There are many important branches of learning, the importance of which man was slow in recognising and the study and application of which are vitally necessary for his well-being. Materials handling is one of these, and only recently has it received recognition and study as a separate technology. It is interesting to observe that Oliver Evans first advertised in 1791 that he could save at least half the labour cost of "attending a flour mill."

Materials handling is an integrating subject. It will readily be seen that it is an essential factor in primary production, manufacture and distribution. In manufacture it vitally affects the layout of the establishment, the design of the product, and the processing. It is an important factor which has to be considered by operators and management. Economics, electronics, and industrial psychology are some of the subjects which come within its purview.

Definitions

No new technology can progress unless the terminology is clear, that is, all matters have been clearly defined and illustrated. It has been well said that "define, and your reader gets a silhouette ; illustrate, and he has it 'in the round.'"

Materials handling may be defined as the movement of everything within an establishment. This includes the handling and movement of raw materials, components (between operations), stores, finished product, scrap, cutting oils, and process machinery ; also the movements of workpeople in relation to the handling of material. A closely allied term calling for definition is materials processing, which embraces the operations which change its form, or its properties, or indicate its quality (inspection and testing). It should be emphasised that, particularly in manufacture, the handling cannot be considered without the processing, and *vice-versa*.

When the handling of materials cannot be done efficiently by hand, mechanical equipment should be put in to do the work. This is then termed mechanical handling, and can apply to both materials processing and materials handling. Mechanical handling brings with it its own problems of definition, and there is a real need for standardisation of the terminology relating to the equipment used.

Scope of Materials Handling

Materials handling is an over-riding integrating subject which is good from more than one point of view. The danger of specialisation to-day is very great and possibly one of the reasons for this is that it is easier to specialise than to study a wide range of subjects. Men tend to know more and more about less and less, so that those in the vanguard of thought and research in even adjacent fields find it difficult when they meet to comprehend one another's language and appreciate the meaning of one another's discoveries. Increasing knowledge involves increasing ignorance.

Because materials handling is an integrating subject, the part taken by architects, structural engineers, lighting engineers and designers must be co-ordinated with that of the materials handling specialist, and, in many cases, it is subsidiary. Therefore, the materials handling engineer must hold a senior position.

Layout is just a part of materials handling and materials processing. Planning and organising are among the most important factors involved in these subjects, and the latter, that is organisation, cannot be stressed too strongly. At this point mention must be made of the great assistance rendered by flow and work movement charts and three-dimensional models in planning and organising.

It should be remembered that, among other advantages, the use of mechanical handling equipment allows much heavier and/or larger loads to be lifted at one time than is possible with manual labour alone. Also material can be stored to much greater heights. Full use should always be taken of these two important features.

The product must be designed from the point of view of the handling and processing. An example occurs in the handling of large sheet steel pressings ; normally such material is difficult to handle. When the handling is considered in the basic design stage often this problem can easily be overcome. If we go into rather more complex fields and consider mass-produced electronic apparatus it will be seen that the design and the handling must necessarily be co-related. Thus the printed circuit is possibly the only solution to large-scale mass production of electronic control mechanisms.

Again there is often no clear line of demarcation between work study, and in particular motion study, and materials handling and materials processing. If motion study is considered from the point of view of its application to an operator, it can be seen that it is for the handling or processing engineer to say if it is a job for hand labour and then, if so, to bring in the time and motion study man, just as a qualified medical man may hand a patient over to the physiotherapist. An example of this occurs in colour sorting. However brilliantly the work position could be laid out, it is for the engineer to say whether an electronic light cell might be used. If such equipment is employed an operator can have an output one hundred times greater than his fellow working without it, but having the finest work position. Other simple examples occur in the positioning of conveyors and the use of automatic screwdrivers.

Another important viewpoint which is often overlooked is that materials handling equipment must always be regarded as a labour aid. This attitude should be well explained to the operator.

Materials handling has important applications in establishments of all sizes. It may not be long before the automatic factory will be here, no doubt controlled by an electronic computator. This may occur first of all in the manufacture of electronic equipment. Labour in that case will be upgraded to purely maintenance duties. Therefore, the repair shop of such a factory will have its own handling problem as will the factory which manufactures specialised equipment, possibly no more than one off, for these automatic factories. Again, industries which produce highly specialised products, articles like jet aircraft, will always form an important branch of the economy of this country. Therefore, a very important branch of new materials handling applications lies in the jobbing and batch shop and workshop, and this may be true to an increasing extent in the future.

As with all new technologies it is very necessary to develop fundamental principles. It is very important to consider the general case with all the variable terms present; the general case can then easily be applied to a particular example by omitting certain irrelevant terms. If a manufacturing plant is considered, obviously the handling study should start at the factory of the suppliers and finish at the factory or other point of usage. There is the transport to the factory; storage; manufacture (departmental and inter-departmental movement and storage) and storage internally; and then transport from the factory. If an expression is developed to take into account all these factors and is applied to warehousing, two items are ignored.

One of the main fields of future developments in materials handling will be in refined methods of operating present-type equipment. For example, much can be achieved by using simple equipment with electronic instrumentation and control. Another very fruitful field will be the integration of the handling and the processing.

Introducing a Handling Scheme

It can truly be said that materials handling has not been studied nor applied in industry to any great extent in this country. There are two main factors to consider in the introduction of a materials handling scheme—the Human Factor and the Technical Factor—both of which must receive careful attention. The method of introduction depends upon whether the scheme is going into a new or an existing plant. When considering the latter (it is the more important at the present time) it should be emphasised that not enough instruction and information are made available to staff and operators. This can be seen in the economic field as well as the technological field. The average man has had possibly over 100 years of training in political matters but none whatsoever in economic affairs. For a successful installation it is necessary for suggestions to come from foremen and operators. Therefore, they should receive instruction in this new technology so that their suggestions will be constructive. If pressure can come from the bottom as well as from the top, the country will be well on the way to achieve the very necessary goal of higher productivity.

Re-education

In some industries a very lengthy period of re-education would appear to be the only solution to break old practices and to introduce new methods. Restrictive practices in many cases are based on false promises, and can only be overcome by education administered over a period of time depending upon how deep their roots go.

The fact is often overlooked that good handling takes the effort out of the work and therefore allows older people to be employed in industry. It is often said that this is an "ageing country," *i.e.*, that the average age of the population is increasing year by year. This point alone is worthy of serious consideration.

Obtaining Advice

A difficulty which besets the average industrialist is that of obtaining correct advice. This applies particularly to the smaller and medium size concerns that obviously cannot employ a specialist on their staff, in fact some of the larger concerns are only now employing materials handling engineers. If they appeal to manufacturers of mechanical handling equipment they feel, quite naturally, that the sales engineer will have the sale of equipment, and his own in particular, as his primary objective. Even if this engineer were willing to make other suggestions, he may be handicapped in that he probably has only experience of the applications of the equipment manufactured by his firm. The small firm, too, may be diffident about employing a consultant as quite often the plant is situated away from the larger centres of population. It has been suggested previously by the author, that there should be a centralised pool, with local centres, of materials handling engineers who could act as consultants.

An interesting observation that can be made by many people in contact with industry, is the lack of knowledge of the equipment that is available and its correct application. So often could certain problems be solved by the use of simple equipment, yet the most complicated devices are seen in use. This danger of over-mechanisation, with its resultant lack of flexibility, has an interesting similarity to some of the paper systems that untrained people have been allowed to inflict upon many organisations. Bound up with this is the incorrect application and lack of knowledge of known principles. Examples of such principles are the straight line rule, the terminal efficiency rule, and that of energy conservation. How often is the simple fact forgotten that each time a worker bends down to pick up an article he is lifting a large proportion of his own body weight? Thus energy is lost which could be better employed in useful work.

The Need for Greater Sales of Equipment

There is scope for much more materials handling equipment in industry. The Information Division of the Treasury gives some interesting figures. These show that the supply of materials handling equipment to home industry in 1951 increased by 4% over the previous year. It should be well noted that the supplies of office machinery rose by over 8%, those of machine tools by 16% and chemical plant by more than 20%, to quote a few other items. It will, of course, be appreciated that these figures are not very accurate due to the difficulty of placing various types of equipment in their respective categories but, nevertheless, the trend is clearly illustrated.

Now, how does this apply to the smaller concern? The figures given by the Ministry of Labour Gazette, June, 1950, pp. 180–190, show that, in the case of manufacturing concerns, of the total of 55,129 establishments (for which returns were received) with more than ten employees, 41,423 or 75% had less than 100

employees, and 15% had 100–250 employees. Establishments with 250 employees or more thus represented 10% of the total. The under-100 range accounted for 22% of the total number of employees, whereas at the other end of the scale the 342 establishments with 2,000 or more employees accounted for 18% of total employment.

From these figures the conclusion is very quickly drawn that if productivity is to increase the smaller firms also must use the most up-to-date methods, for approximately half the total number of workers are employed in establishments having less than 500 employees.

As has been pointed out, modern materials handling methods do not apply alone to the large mass-producing industries (as do the large conveyor installations, a point which often causes confusion), but can be utilised in all sizes of works.

It may be emphasised that the above figures relates only to manufacturing concerns, whereas materials handling methods and equipment are utilised in many other types of establishments, e.g., warehouses, docks, railway terminals, stores, abattoirs and breweries.

Possibly one of the reasons why materials handling is only in its infancy is that there is still not much competition to-day and therefore little incentive. Managements do not yet realise the great savings that can be made by the application of these new technologies, and workers the fact that their jobs vitally depend upon the very rapid introduction of the new methods in their works.

Education and Training

Even in the United States, education and training in materials handling leaves much to be desired and it is interesting to quote from a leader in *Modern Materials Handling* of February, 1952, in which it is stated :—

"... However, we all should be concerned because neither adequate depth nor breadth yet exists in materials handling education. Materials handling needs recognised authorities who are completely detached from commercial interests. We need men who have the time and facilities to develop principles, analytical techniques, and to accumulate materials handling data useful to everyone.

"Although many manufacturers are highly skilled in the application of their own equipment, we have no comprehensive body of organised materials handling knowledge. The principal men who can and should assemble and correlate this knowledge are the educators. And they need two things from the materials handling industry — inspiration and financial support ..."

It can be said that the same position exists in this country to-day. There is no research to my knowledge at present being undertaken in any British University dealing with materials handling and allied fields. The sooner such research is undertaken the more quickly will this new industrial technology be universally recognised. It is imperative, therefore, that post-graduate work for higher degrees, such as the M.Sc., and the Ph.D., should be commenced in the Universities as soon as possible.

It is for firms interested in this field to find the money for such work to commence. Many other industries, *e.g.*, the electrical, the chemical, and the aircraft, have proceeded along these lines with very fruitful results, and have also endowed Chairs in the fields which concern them.

It would not be long then before the subject was taken in the Bachelor's Degree. The paucity of properly trained lecturers in this and other industrial subjects is alarming, and unless some such procedure is taken as I have suggested it will remain so.

Manufacturers' requirements are for men with a wide experience not of one industry nor of materials handling alone, but, for example, with a knowledge of processing. A proper fundamental training is necessary, then practical experience. It is worrying to see untrained personnel dealing with complex matters in this field. It has been well said that an engineer is a man who can do for one pound what any fool can do for two. Experience by itself is a slow teacher, and it is therefore necessary to combine theoretical training, observation, practical experience and discussion. Industry generally must be prepared to pay good salaries to attract the right type of men, and should remember that an inferior article is dear at half the price.

Miscellaneous Observations

It is often forgotten that co-ordinated inter-departmental planning is necessary not only in respect of equipment that is common to more than one department, but also in the form which material is handled in any department. Again, the manner in which material is despatched is of vital concern to the receiver, and more collaboration is needed between suppliers and users than generally exists to-day.

Malpractices often occur in the use of elevating and fork trucks. It is quite common to see fork trucks travelling long distances, sometimes over public roads, in many factories, and often there has never been any attempt to organise a basic system. All trucking systems require careful organisation. It should be remembered that ideally a fork truck ought never to travel more than two or three hundred feet, for it is essentially a lifting device. Local conditions and requirements vary, but it is desirable to adhere as closely to this rule as possible.

There are many ingenious applications to which stillages can be put. A work bench can be made in the form of a semi-live stillage and thus can be easily moved by the tug lift. This type of bench is useful in motor vehicle maintenance shops.

A common fault of portable equipment is that such devices are sometimes too heavy and one wonders if the units have been stressed and designed at all. Portable hand jib cranes and gantries should be light in weight so that they can be easily moved around the shop floor.

Power-operated trucks for indoor use should be battery-electrically operated. Apart from the advantages that the battery-electric vehicle offers, *e.g.*, low maintenance costs, ease of driving, cleanliness and silence, all matters which are of extreme importance, it is to be noted that there can be nothing more distressing to machine operators than to be constantly engulfed in the irritating fumes of the compression-ignition or petrol engine. Whether or not the fumes are injurious is not at present known, but they are unpleasant and tend to lower the operator's efficiency.

Runways are often incorrectly used. A common example is the positioning of a runway with lifting blocks in the form of a cat-head when a self-landing hoist is more efficient in every way. A common sight in stores

is runways down the centres of the aisles which are used to stack material to one side and/or the other of the runways. Stacking can be done to a certain height depending upon the height of lift but " air-rights " cannot be used fully. If an overhead means of lifting is the correct method to employ, then small underhung cranes should be used. A direct lift is thus obtained and a complete coverage of the area is effected. Particularly so if one of the advantages of the design is used, for example, the ability to latch a crane to a runway. It may be emphasised here that underhung cranes are not used enough in this country. The possibility of latching the crane to runways or to another crane permits a very flexible system to be designed.

The principle of integrating the handling and processing must always be kept foremost in mind and even with simple systems much can be achieved. For example, weighing should be carried out if possible while the material is being moved. This can be done on a runway system by having a section of the track " floating " and acting as one arm of the scale, so that when the trolley with its load comes on to this section, a recording of the weight will be obtained. The weighing of material on slat and belt conveyors can be similarly undertaken.

Very often two machines can be very simply combined and an example occurs in side- and end-sawing operations. If the machines are positioned at 90°, the side-sawing machine receiving the material first, then the work coming out of this unit is in the correct position for the end-sawing operation to commence without any intermediate handling.

Standard speeds of lifting equipment should be used whenever possible. In general no advantage is obtained by having high speeds of lift or travel; it is more satisfactory to have high rates of acceleration and deceleration, together with properly placed controls.

Gravity is extremely useful for feeding not only machines but vans and lorries in loading bays, and whenever possible a length of roller conveyor or a chute should extend so that it goes into the van and is pushed out step by step by the loader as the van is filled up.

Electrical vibrators have a large field of application. Belt maintenance can be reduced very considerably if small angle vibratory chute feeds are used for loading belt conveyors with bulk material from hoppers. An interesting use of a vibrator is in connection with the unloading of bulk material from a lorry. If a vibrator is permanently mounted in a suitable position on the side of a lorry platform, it will be found that the tipping of materials which tend to " pack " during transit is very considerably speeded up.

The general method of delivery of materials, whether in bulk form or as unit articles, always needs careful consideration. There are to-day many appalling examples of time wasted and lorry turn-round times running into hours. Often considerable savings can be obtained by simple methods and an illustration occurs in the delivery of paint. If large returnable tanks are used instead of non-returnable drums, a saving immediately occurs in the wastage which invariably remains at the bottom of each drum after emptying, and in the time of unloading and the cost of the paint. Another example in a different industry is the delivery of milk. Some years ago this was ladled out of a large churn on a horse-cart, and delivered in a can to the house. We are now at the intermediate stage in which the milk is bottled at the dairy, the full bottles are delivered by electric vehicle and the " empties " then collected. The next stage will use the expendable (non-returnable) waxed paper or plastic carton. The collection of the " empties " will be completely eliminated.

I mentioned earlier in this paper the great possibilities offered by electrical methods of instrumentation and control of materials handling equipment. However, careful selection of equipment is necessary, as always. Light cell counters have many uses in industry, but it is not good practice, for example, to use such a unit for the counting of beer bottles passing on a conveyor when a simple mechanical counter operated by a star wheel rotated by the bottle-necks will do the work simply and cheaply. Again, there is no point in installing colour selection equipment if the different coloured material does not need to be mixed during the processing. Coloured crayons are an example. Each colour comes from one particular extrusion machine and can easily be fed into a separate hopper. Thus there is no need to feed all the colours into one hopper and use an electronic sorting machine to sort the colours out for filling the cartons.

Conclusion

An attempt has been made in this paper to emphasise some of the more important facets of this technology which, like truth, is a many-sided jewel. The most important facet of all, is that Materials Handling is the only field which will yield the important and substantial increase in productivity which is necessary in British Industry to-day.

£4 Million Bridge Contract

THE Auckland Harbour Bridge Authority, New Zealand, have accepted the joint tender of two British firms—The Cleveland Bridge and Engineering Co. Ltd., of Darlington, and Dorman, Long and Co. Ltd., of Middlesbrough—for the construction of a new road bridge at Auckland. This was the only British tender submitted and had to meet strong foreign competition, particularly from Continental bridge builders. The value of the contract is £4,236,000. Each of the firms will fabricate approximately half of the steelwork and will work in association on the construction of the foundations and erection of the superstructure. The weight of steel in the bridge is approximately 10,000 tons and it is anticipated that the bulk of this material will be rolled in Dorman Long mills. The bridge will satisfy an urgent need in Auckland and has been under consideration for many years. Traffic across the harbour is at present carried by ferries and congestion is severe.

The overall length of the bridge works which link the City of Auckland with the Borough of Northcote is 3,520 feet and includes an 800-foot span over the navigation channel, and six other spans. Designed in high tensile steel of standard structural quality, the bridge superstructure consists of a series of cantilever truss spans. The navigation span and the two adjacent spans are linked together and connected to the North anchorage. At the third pier there is an expansion joint in the structure and from there to the South shore the four tapering approach spans are similarly linked by pin-joints and connected to the South anchorage. The navigation span gives a maximum clearance above high water of 142 feet.

The Research and Development Division of the British Steel Founders' Association

By J. F. B. Jackson, B.Sc., A.R.I.C., F.I.M.

Director of Research

The Research and Development Division of The British Steel Founders' Association is one of the youngest of the co-operative research organisations, but in the first three years of its existence it has made considerable progress. Following a brief discussion of its method of operation, reference is made to a number of projects in hand, including investigations into foundry methods, not forgetting the health aspect, and into the properties of the finished castings.

PRESENT indications are that Research Association status will by the end of this year be assumed by the Research and Development Division of the B.S.F.A., and this occasion may well, therefore, be the last of its kind upon which this organisation is referred to under its present title. Emergence, however, of the Division as the British Steel Castings Research Association will signify no essential change in its *modus operandi*.

The September, 1951, issue of this Journal outlined the original purpose and general policy of the B.S.F.A. Research and Development Division, which it may be recalled was established by the steelfounding industry in 1949 and, on the disbandment of the Steel Castings Division of the B.I.S.R.A. in 1951, became the industry's sole organisation for co-operative research.

Nineteen fifty-two has been a period of both expansion and consolidation. The account that follows provides some indication of the general activities of the Division during this third year since its formation and refers to specific aspects of research and development that may be of interest to those outside the industry.

Research Stations and Laboratories

Early in 1950, when the Division had no buildings, equipment or research team of its own, a series of research projects was initiated in various universities. Each of these projects was of a long-term character and of a type suited to university working conditions and environment. It was, however, envisaged at the time these early researches were sponsored, that other types of research—unsuited to the treatment and facilities peculiar to the universities—would require to be undertaken by the Division's permanent staff as and when appointments were made. It was at the same time visualised that such permanent staff would work either in the foundries or laboratories of Member firms or within similar facilities operated by the Division itself. Both types of project have since emerged and have, in fact, been handled in each of these ways. It was, of course, recognised that all research or development projects are to be regarded as having to pass through one or more phases in the course of their prosecution, such phases clearly ranging from the preliminary search for published relevant data to the other extreme of full-scale production trial and application; the obvious importance of selecting the right location for any particular phase of a research project was similarly appreciated.

In addition, therefore, to the facilities for research afforded by the universities undertaking extra mural research work on behalf of the Division, arrangements have been made at the Division's headquarters in Sheffield to provide not only various basic laboratory services but also laboratory space for research work undertaken by the Division's permanent staff. These arrangements have been supplemented for immediate purposes by facilities made available within the University of Sheffield where, in the Refractories Department under Dr. J. White, the testing of refractories, clays, core-binders and sands is undertaken.

In this manner, and with the additional assistance of the laboratories of Member firms for mechanical and other testing, the Division's requirements in respect to service and research laboratory facilities have been satisfied and will continue to be provided for, at least until 1954.

On the other hand, while a relatively large proportion of the foundry process and plant engineering work on the Division's programme is already being undertaken through facilities available in Members' foundries, there is an increasing number of projects which for satisfactory execution require conditions and facilities—a closer degree of experimental control and freedom from interference with and from shop production—which can only be afforded through the medium of experimental units or research stations. The Division established its first research station in Sheffield towards the end of 1951, and plans are now going forward for the establishment of a second unit which is intended to come into operation by the end of 1953, and which will very largely extend the Division's facilities for essential work on pilot plant or full industrial scale.

It has previously been stressed that it is the Division's policy at all times to take whatever steps may be necessary in order that its results shall ultimately be available in such a form as to be applicable by industry, and the recognition that research and experimental stations form a vital part of the organisation's facilities gives tangible confirmation that this policy is being pursued to the full.

Discussion Groups

The problem of translating the results of research and development into practice is, of course, by no means new, and its existence was fully recognised in the steelfounding industry by those who were responsible for the formation of the Research and Development Division of the B.S.F.A. This was clearly shown in the announcements made in the press at the time when the Division came into being in 1949.

It is not regarded as sufficient that the Division should rely upon its own printed publications for transmitting to its Members information that arises either from its own work or from the work of others. The written word is regarded as providing a necessary detailed record, but however attractive, interesting and intelligible it may be in its presentation, it is known that it goes only a very little way towards bridging the gap between the finding of information and the putting of it into practice. The spoken word in the form of lectures goes perhaps a little further, but in this important operation of " gap bridging " it is realised to be very far from successful. The spoken word, however, in the form of discussion between those in industry responsible for applying research and development and the Division's permanent staff, is regarded in an entirely different light. Discussion of this sort is considered to achieve a significant effect, and for this purpose during its third year of operation the Division has stimulated, on a regional basis, Technical Discussion Groups for the particular purpose that has been described.

Meetings of the Discussion Groups are attended not only by the senior technologists and shop superintendents of Member firms but also by staff and operators from the shop floor in whose hands, literally, the ultimate application of research and development findings is known to lie. It is felt that where all concerned can discuss and, for preference, be shown, by film or by direct demonstration, the value of a technique or process, then there is at least a chance that that process will be understood and applied.

The use made by industry of the results of scientific research has latterly been the subject of particular attention in Government circles, and while the opinion has been expressed that there is great scope for the exploitation of popularly written reports and statements dealing with such results, the suggestion is discounted as having relatively little value in practice. The Division's main machinery for " bridging the gap " is based preferably upon discussion backed by demonstration, discussion taking place at all phases in the prosecution of the research project progressively from Specialist Panels, through Standing Committees to Regional Discussion Groups and the individual Member firm. Demonstration directly to those concerned in the application of the technique then follows, this taking place in the Division's Research Stations or in Members' works, according to the nature of the development, with the additional support of motion films available either regionally or to individual members. There can be nothing more certain than the fact that the potential users of research in industry can neither believe nor be convinced unless they see for themselves that the results of research are all that they are claimed to be, and that they unquestionably fit into industrial practice. In this process of seeing and believing, the Division's Regional Discussion Groups, which have come into operation at a time when tangible results have begun to flow, play a major and even a vital part.

Publications and Information Service

During the Division's second year it commenced the publication on a bi-monthly basis of a Journal of Research and Development, for the particular purpose of keeping its Member firms continually posted of the progress and of the results of the various research and development projects in hand. The circulation of the Journal, which is, of course, restricted, also conveys to its recipients information relating to developments in steel founding technology and science that are of importance to the industry, regardless of their origin. The Journal is also a convenient medium for the dissemination of incidental information of interest and value arising from the deliberations of the Division's Standing Committees and Specialist Panels.

The Library and Information Department of the Division came into operation in September, 1950, since which time its scope and services have been progressively extended. In addition to meeting the usual requirements from industry for loans of published works and for information upon specific problems, it is, of course, an essential function of the Information Service to survey current literature related to steel castings science and technology, and to abstract and publish such information in classified form. This is achieved through the medium of the Division's bi-monthly publications of Abstracts which is automatically forwarded to the Members of the Division as it is issued. As the main source of information upon which the Abstracts are based, the Division receives some ninety publications of British and overseas origin. Facilities are also available to any Member who, through the Information Service, may wish to obtain translations of foreign articles or to borrow scientific films or lantern slides for lecture purposes. While the provision of an Information Service is one of the essential functions of an industrial research association, the mere accumulation of information cannot be regarded as an end in itself. The value of such a service is regarded as lying in the promptness and clarity with which enquiries by those in whose interests it is provided can be answered ; similarly, the measure of that value is the frequency with which enquiries are made and satisfactorily met. In addition to the Journal of Research and Development and the Abstracts, the Division issues to its Members at appropriate stages in the course of its work, Research and Development Reports, each of which relates to a particular major project which may have been completed or have reached a stage suitable for the issue of an interim statement. Research and Development Reports are normally restricted in their circulation but, depending upon their nature, may be made available on a wider basis. A recent Report (No. 16/51/MM), dealing with the properties of a series of thirty-nine bonding clays and their characteristics, has been widely acclaimed in the technical press and enquiries for the purchase of the Report have been received from many sources not only in this country, but on the Continent and in the U.S.A. and Canada.

Properties of Steel Castings

There has for many years been a diversity of opinion regarding the relative mechanical properties of steel castings produced by the acid and basic electric arc, and by the Tropenas converter processes in particular, and with the assistance of the Metallurgy and Quality Committee (Chairman—Mr. C. H. Kain, A.M.I.Mech.E., F.I.M., Lake and Elliot, Ltd.) the Division has conducted a survey of mechanical test results obtained from various sources. In view particularly of the increasing requirements of engineering design, it was considered important that the inherent performance of steel castings produced from steels of different origin should be established in quantitative terms and in relation to existing British Standard Specifications.

For purposes of comparison of steel quality, it was considered appropriate to assess this in terms of the ductility exhibited at various tensile levels. On this basis it has been shown that the most consistently high ductility figures are exhibited by steels produced by the basic electric arc process, and that converter steels, while capable of giving excellent figures, tend to be less consistent although, of course, satisfying the requirements imposed by the appropriate material specification, i.e. B.S. 592 : 1950. The extent to which such observations are a reflection of the lower sulphur and phosphorus contents of basic electric steel is being examined further. The chemical compositions of several hundred heats from each steel-making process are being examined in relation to all the normal elements reported in carbon steels, and it is hoped that statistical treatment may yield data which will indicate the extent to which the observations mentioned above are attributable to the normal differences in composition arising from the steel-making process, as distinct from such other factors as gas content or tapping temperature.

The investigation referred to is incidental to the Division's major programme of research into the properties of steel castings, which is aimed essentially at establishing basic data for design purposes, and at making good deficiencies in this field of knowledge which, it must be recognised, still persist. While data are available in relation to sub-zero and elevated temperature properties, to the effect of mass or section upon the ductility and notched-bar impact resistance and to the influence of composition on these characteristics of steel castings, much that has been published lacks background information relating to such essential aspects as method of steel manufacture and heat treatment conditions, and it is known that for some considerable time to come the collection and collation of results already available will provide material for a major investigation, quite apart from the need to obtain further data in order to keep pace with those changing and increasing standards which are the natural outcome of engineering progress and development.

The Division's studies relating to the mechanism of freezing, which clearly exercises a fundamental control upon the mechanical properties of the finished casting, have yielded important results based upon the use of radioactive isotopes. In particular, these findings emphasise the importance of convection in the proper understanding of the freezing process, and it is possible to foresee this essentially fundamental work producing information that may well in the next two or three years have application in practice, and thus have a direct bearing upon both internal soundness and upon mechanical properties.

Non-Destructive Testing

While it is unquestionably of importance to the engineer to know the inherent properties of a steel casting as determined by the test performance of the steel from which the casting has been made, for important engineering applications it is most necessary that reliable information is also available as to the structural soundness and internal continuity of the casting in all its highly stressed zones. The use of radiography, using various sources of radiation, has become increasingly common practice, particularly during the last ten years, but the fact remains that the radiographic exposure of all but the thinnest sections of steel is still a time-

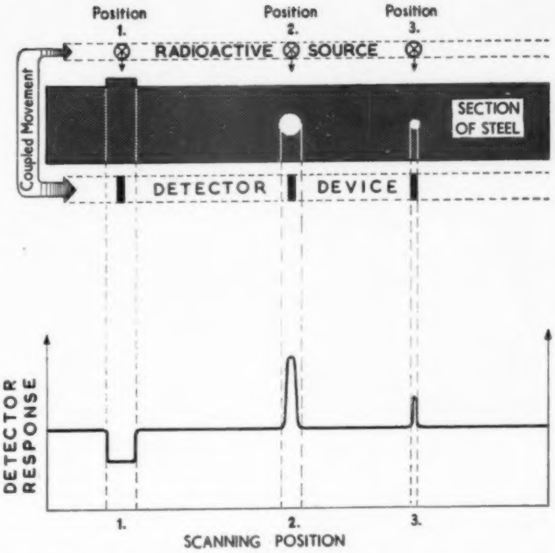


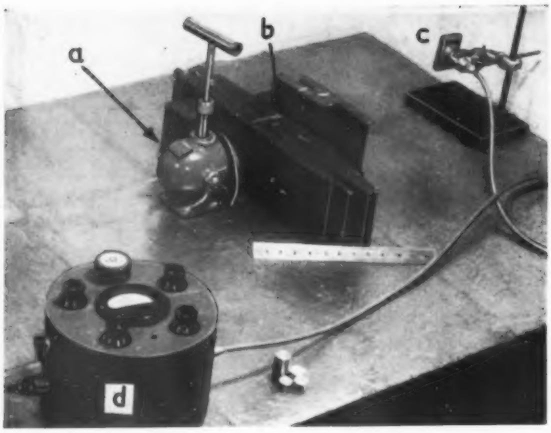
Fig. 1.—Diagrammatic illustration of the technique of radiological scanning.

consuming operation. It has been appreciated that the availability of an alternative recording technique, not subject to the limitations of film cost and exposure time would be a matter of considerable importance, particularly insofar as castings of relatively heavy section are concerned, and the Division has, during 1952 and previously, been examining the possibility of employing an entirely different technique which is illustrated schematically in Fig. 1.

Instead of attempting to reproduce a complete radiographic shadow pattern on a film, screen or plate, the experimental technique has involved a procedure of "scanning" a casting progressively, area by area, using some suitable form of radiation detector cell capable of recording such changes in the transmitted intensity as may arise from internal or external change in sectional thickness. On the one hand, a scheme has been visualised in which the radioactive source (or X-ray tube) is stationary at some distance from the specimen and the detector cell is made to scan the radiographic image formed behind the test specimen. Alternatively, the radiation source can be arranged to move in sympathy with the detector cell, this being the procedure indicated in Fig. 1.

It will be appreciated that the development of a technique based upon this principle is primarily dependent upon the availability of a suitable radiation detector cell, which must not only be capable of resolving small changes in radiation intensity but must also be of a size small enough to permit geometric resolution of the shadow pattern.

Fortunately, of recent years, the development of various devices for detecting and measuring radioactivity has been proceeding rapidly and while the Geiger-Müller counter has proved to be insufficiently sensitive to be of value for the "radiological scanning" of steel castings, a device developed by the Berthold Laboratories in Germany, based upon the use of a bank of small Geiger-Müller tubes operating a single rate of count meter, has shown promise. In preliminary tests, using a small



a Radiation source.
b Test specimen
c Berthold tube.
d Rate of count meter.

Fig. 2.—Experimental set-up for radiological scanning using a Berthold tube.

source of cobalt$_{60}$, it has been shown that the Berthold type tube is capable of detecting a 5% cavity in as much as 8 inches of steel. The arrangement of the apparatus for experimental purposes is shown in Fig. 2.

The further development of the technique is in the hands of the Division's staff in the Broomgrove Lodge laboratories, and is a matter of particular interest to the Division's Non-Destructive Testing Panel (Chairman—Mr. G. T. Harris, M.A., F.Inst.P., F.I.M., William Jessop and Sons Ltd.).

Fettling and Dressing of Steel Castings

While an important series of the Division's investigations is directed towards improvements in the surface finish of steel castings, including the elimination of adherent metal-penetrated moulding sand, the magnitude of the problem in general is such that, although improvements are not unreasonably anticipated, it would be quite unrealistic to suppose that the need for final dressing or fettling operations will disappear entirely in all foundries within the foreseeable future. A parallel series of investigations is therefore in hand simultaneously to examine in detail each of the several methods of fettling which is at present applied, with a view to its improvement in speed, cost and effect upon the operator.

The use of the pneumatic chisel is common to most steel foundries and, while its effectiveness in relation to the hand hammer and chisel which preceded it is not in question for most purposes, its noise, its production of fatigue in the operator, and its production of dust have caused this tool and its operation to receive preferential attention.

For immediate purposes the attack upon the problem has not been directed towards the pneumatic chisel itself, but rather towards seeking an alternative means of performing the same fettling operations. Of the several possible alternatives considered when this work was commenced during 1950, the technique which uses an oxy-acetylene flame into which is injected a flux, such as iron powder, was judged to offer attractive possibilities, provided that a modified type of burner could be developed which would be capable of removing thin layers of metal-penetrated sand from the flat surfaces of steel castings.

Recent developments in this country, achieved by the British Oxygen Co. Ltd. in conjunction with the Division, have led to the availability of what was originally termed a "flame chisel," employing an oxy-acetylene torch into the flame of which iron powder is injected by an air-stream. The intense heat generated by the oxidation of the iron and the combination of its oxides with the adherent silica sand have proved successful in many applications, and as the technique finds extended application within the industry, it is likely that the use of the pneumatic chisel will be proportionately and increasingly superseded.

It is probable that other techniques under development will supplement the "flame chisel" in further limiting the need to employ the pneumatic chisel.

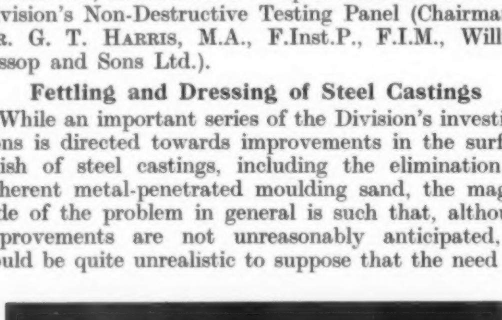


Fig. 3.—Dust Research Station photograph (un-retouched) showing output of fine dust from stand grinder unit.

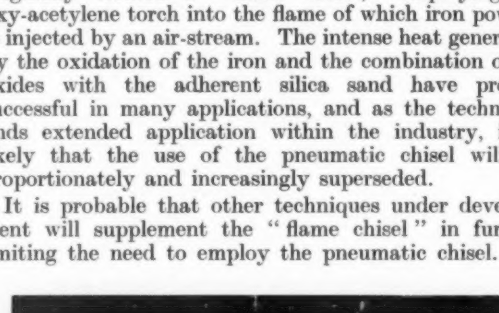


Fig. 4.—As Fig. 3—same grinder unit with modified exhaust system.

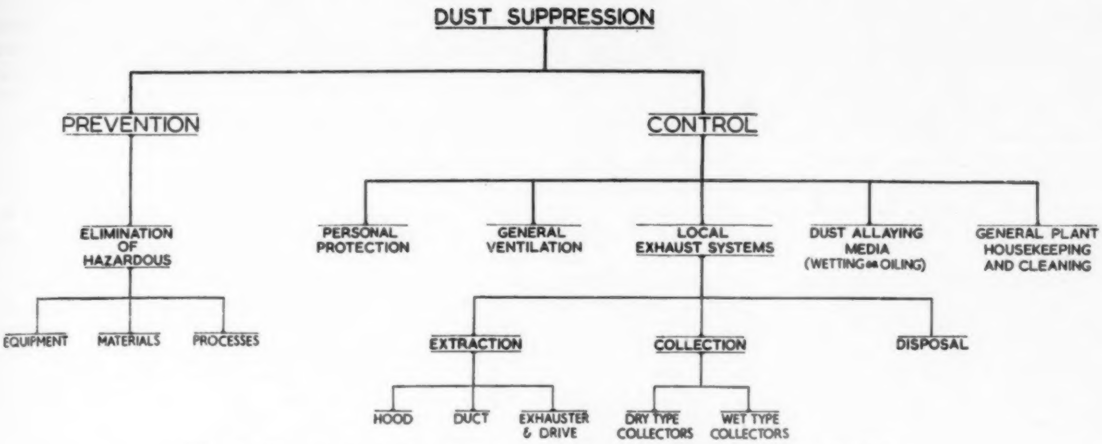


Fig. 5.—Dust suppression terminology chart, as adopted by the B.S.F.A.

Dust Research

The suppression of dust in steel foundries, both by its prevention and control, has continued to represent a field of research of major importance. Towards the latter end of 1951 the Division established a Dust Research Station in Sheffield solely devoted to this problem, and in particular to the study of local exhaust systems. Studies have been made of stand or pedestal grinding units employing grinding wheels up to 24 in. and of various forms of swing-frame grinder, and it has been established beyond question that both these basic types of foundry equipment are amenable to modification and improvement in such a way that their local exhaust systems can be rendered very much more effective than has hitherto been the case. Experimental work continues with the object of defining the optimum form which the new systems should assume, but reference to Figs. 3 and 4 will indicate qualitatively, but nevertheless impressively, the extent to which the output of dust to atmosphere from this type of plant can be reduced.

In its researches upon the stand grinder problem, the Division has had wholehearted co-operation and assistance from the Ventilation Committee (Chairman—Mr. G. E. Lunt, Bradley and Foster Ltd.) of the Foundry Trades' Equipment and Supplies Association which has, without charge and at short notice, made available various stand grinder and dust collector units. As a matter of policy, it is felt to be vitally important that where it is found necessary from the steelfounder's point of view to modify or improve any particular type of foundry plant or equipment, the manufacturers concerned should from the start be associated with the investigations that are to be put in hand. In the particular instance cited, the F.T.E.S.A. has not only responded generously with equipment, but with advice and help towards the solution which both industries wish to see established and applied.

At the instance of the Committee on Industrial Health (Chairman—Mr. D. W. L. Menzies, Bonnington Castings Ltd.) of the B.S.F.A., the Division is proceeding to consider the design and efficiency of foundry mould "knock-out" systems which, particularly from a practical standpoint, involve problems of considerably greater magnitude than those presented by the two types of equipment mentioned earlier. In the steel foundries, therefore, local exhaust systems are being given priority over general ventilation, as it is with good reason believed that the quickest and the greatest improvements will be forthcoming in this way.

The attack upon the steelfoundry dust problem is being carried out by the Division on a broad front, as is typified by Fig. 5. This chart, in addition to giving a simple breakdown of the main problem of dust suppression, provides a standard terminology which has been adopted by the Division and by its Plant Engineering Committee (Chairman—Mr. R. F. Ottignon, K. and L. Steelfounders and Engineers Ltd.).

Hot Tearing

The Division's researches upon the problem of hot tearing in steel castings are directed towards determining the effect of various moulding materials, rather than of steel composition, upon the incidence of this type of defect. While it is anticipated that the results of some of this work will be available for publication during 1953, the type of test apparatus devised for investigation purposes may in the meantime be of interest and is

Fig. 6.—Apparatus for investigation of the influence of mould materials on hot tearing.

shown in Fig. 6. The test casting is a square-sectioned bar which has its in-gate at one end, restriction to contraction after pouring being given by a calibrated spring (*a*) and by the test core (*b*). In this way a closed stress system is produced, the load causing deflection of the spring being equal to that in the bar and also to that exerted on the test core by the runner. In the event of the test core collapsing as the cast bar contracts, no stress is induced in the casting and, therefore, no deflection of the spring occurs. If, however, the core remains intact and restricts the contraction of the casting, a stress is induced in the casting by the deflection of the spring. Similarly, if the moulding material exhibits high resistance to contraction during the hot-tearing range, tearing will occur at the hottest spot in the casting, i.e., at the junction of the runner and bar. The test, therefore, gives a measure of the stresses induced in the casting by the range.

Thermocouples placed in various positions in the casting and the test core determine the temperature conditions obtaining in the casting and the sand at different intervals in time after the filling of the mould.

General

The B.S.F.A. Research and Development Division has some 40 full- and part-time research and development projects upon its current programme, 10 of which are being conducted extra-murally in the universities. Of the latter, a number are concerned directly with industrial health and with steel-foundry dust in particular.

The full breadth of the Division's programme is clearly demonstrated by its organisation of Standing Committees and Specialist Panels, details of which were previously published (METALLURGIA, September, 1951). The five panels previously indicated have, during 1952, been increased to six by the formation of the Refractories Panel (Chairman—MR. W. H. EVERARD, Edgar Allen and Co. Ltd.) the function of which is to advise the Division's staff upon its work in relation to steelmaking and heat-treatment refractories, as distinct from moulding materials.

In line with previous policy, where an identity of interest in any particular field of research exists between other industries and the steelfounding industry, a suitable liaison has been established, in this instance in relation to refractories research, between the British Ceramics Research Association, the British Iron and Steel Research Association and the Research and Development Division of the B.S.F.A.

Blast Furnace Relining Record

THE United Steel Companies Limited announce that No. 9 Blast Furnace at the Appleby-Frodingham Branch, Scunthorpe, has just been relined in the world record time of 24 days.

The furnace was taken off wind on Saturday, 27th September. During the next five days there was very heavy rainfall and high winds, sometimes of gale force, were blowing. Under these conditions the work of top stripping was made increasingly difficult. Not only had very heavy weights to be raised but the men were working at heights up to 180 feet above the ground. During the first 36 hours after the furnace came off blast 426,000 gallons of water were put in to cool down the contents. As soon as the water was turned off demolition started and by Friday, 3rd October, 1,400 tons of old burden, bricks and rubbish had been carted away. The total amount of rubbish removed from the furnace was something of the order of 3,000 tons, in addition to several hundred tons of steelwork that had been dismantled and removed.

The entire project was a typical combined operation and was only made possible because it was entirely conceived and planned on the lines of a grand military operation. Careful planning and ingenious use of existing machinery meant that the job went very smoothly and at the peak period of intensity 150 men were engaged thereon. These worked day and night, under deplorable conditions at times. Special railway lines were laid for conveying materials and the skips normally in use for charging the furnace with coke and ore were utilised for taking away old burden and bringing up new refractory brickwork. The hearth and bosh of the furnace have been lined with carbon blocks and the rest of the stack with refractory bricks. At the same time the furnace hearth was extended from a diameter of 22 feet to 25 feet and it is estimated that this increase in size will produce an additional 600 tons of pig iron weekly on top of the normal 3,800 tons.

It is interesting to note that on the last occasion the furnace was relined (1946) the job was accomplished in 56 days while its sister furnace (No. 10) was relined several years ago in 43½ days. The present time taken of 24 days is 96 days better than the existing national average for this type of job of four months, or 120 days. It will be seen, then, basing the furnace output now that the size has been increased on 4,400 tons weekly or a low average of 600 tons daily, that in the 96 days working time that have been saved an additional 58,000 tons of pig iron has been made available for the country.

The furnace was re-lit at 10-30 a.m. on Monday, the 20th October, by the Reverend J. E. Swaby, the Vicar of Scunthorpe.

Institute of Metals Officers

THE following members have been elected to fill vacancies on the Council of the Institute of Metals with effect from the 1953 Annual General Meeting :—

As President : PROFESSOR F. C. THOMPSON (Professor of Metallurgy, University of Manchester).

As Vice-Presidents : MAJOR C. J. P. BALL (Chairman, Magnesium Elektron, Ltd.), and PROFESSOR G. V. RAYNOR (Professor of Metal Physics, University of Birmingham).

As Members of Council : MR. W. A. BAKER (Research Manager, British Non-Ferrous Metals Research Association) ; MR. J. C. COLQUHOUN (Chairman and Managing Director, The Manganese Bronze and Brass Co. Ltd.) ; MR. E. R. GADD (Chief Metallurgist, Engine Division, The Bristol Aeroplane Co. Ltd.) and THE HON. JOHN GRIMSTON, M.P. (Director and General Manager, Enfield Rolling Mills, Ltd.).

The Council of the Institute has elected DR. S. F. DOREY (Chief Engineer Surveyor, Lloyd's Register of Shipping) to serve as Senior Vice-President for 1953–54, and he will be their nominee for the Presidency in 1954–55.

Corrugated Aluminium-Sheathed Cable

Pirelli—General Production Technique

A variety of methods has been suggested for the sheathing of cables with aluminium and in this article is described the process used by Pirelli-General Cable Works, Ltd. The essence of the method is the production round the cable of an oversize welded aluminium tube which then has its internal diameter reduced to that of the cable by rolling down or corrugating.

SINCE the war the electric cable industry has developed techniques to enable aluminium to replace lead as the sheathing material for underground power and communication cables. Pirelli-General Cable Works, Ltd., and the Research Laboratories of The General Electric Co., Ltd., have collaborated in bringing to the stage of commercial production a method whereby aluminium-sheathed cables having any of the standard types of dielectric can be produced in lengths up to the maximum which it is convenient to handle, in diameters from about half-an-inch up to three inches. A feature of the manufacturing method permits a variation of the degree of flexibility of the cable ranging from that of the cold-drawn tubular aluminium-sheathed cable to that of the traditional lead-sheathed type.

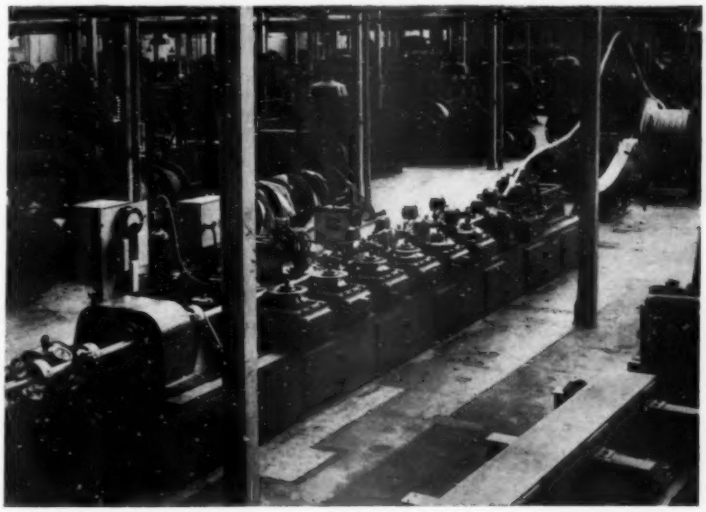


Fig. 1.—The aluminium sheathing machine.

The position since the war has been such that the output of the cable industry has been limited almost entirely by the amount of lead available to it. In 1946 there began a search for substitutes. It was known that, during the war, the Germans had attempted to modify lead sheath extrusion presses to take super-pure aluminium, with some success; the aluminium sheath produced having certain inherent advantages over the lead sheath. A committee of investigation visiting Germany in 1947 confirmed that a small amount of telephone cable had been sheathed by direct extrusion of super-pure aluminium but reported that the optimism of the designers of the extrusion plant was shared neither by the industry nor by potential users of the cable.

From 1949 onwards it was clear that in the United Kingdom aluminium had come to be regarded as an acceptable alternative to lead and that much effort was being expended on the development of methods which would circumvent the difficulties encountered in Germany, the most prominent of these being based upon:—

(1) Drawing insulated core into oversize pre-extruded tube followed by cold-sinking the latter down to the core diameter.

(2) Longitudinal welding of strip formed into tube.

(3) Extruding oversize pipe on to the cable core with simultaneous cold-reduction in tandem with the extrusion.

The second method was selected by Pirelli-General and The General Electric Company, the choice being influenced by:—

(*a*) The success of the already well-established welded stainless steel cable sheath manufactured by Pirelli-General.

(*b*) The unique experience of the Research Laboratories in the development of automatic electric welding equipment.

(*c*) The freedom from the disadvantage of limitation of length to which all the extrusion methods were subject.

The welding technique employed made use of a previously patented twin-arc electrode and control system in conjunction with an inert gas shield.

Argon Arc Welded Aluminium Sheath

The primary step in the manufacture of the Pirelli-General argon arc welded aluminium sheath is that of producing a longitudinal butt-welded tube comparable in uniformity and soundness with extruded and drawn tubes. The plant in which this is achieved is described in the following section.

The need to space the welding heat zone away from the surface of the combustible cable core necessitates a secondary step, in which the internal sheath-diameter as-welded is brought down to that of the insulated core. Two methods, or rather two variations of the same method, are available for this (*a*) rolling down, and (*b*) corrugation.

(*a*) *Rolling Down.*—The plain cylindrical sheath emerging from the welding head is reduced in diameter without alteration of form or appreciable increase in length, the surplus metal being absorbed in uniform thickening of the wall.

(*b*) *Corrugation.*—The effective internal diameter of the slightly oversize welded tubular sheath loosely

Fig. 2.—Tube forming rolls.

enclosing the cable core is reduced by corrugation so that it just embraces the core. The resulting cable is remarkably flexible in the sense that it requires little effort to bend it and in that it withstands repeated bending on diameters appropriate to lead-sheathed cable without damage or undue distortion of the sheath. The bending performance is so good, even with a much lighter gauge of metal than is usual for normal tubular sheaths, that this method is recommended for all cables except those in which the dielectric design would not permit an internally corrugated sheath, and where bending diameter requirements are, in any case, unlikely to produce excessive sheath distortion.

An incidental advantage of the necessity to reduce the effective diameter after welding is that by variation of the depth of rolling-down, or corrugation, a single size of tube, as welded, provides for a range of cable core diameters, permitting an economic design of plant and accessories. The pitch, radius and range of depth of corrugations are graded in relation to the external diameter of the sheathed cable.

Manufacture

Surface Preparation and Forming.—Aluminium strip fed from a coil in a continuous length sufficient for the cable in hand is first passed through rotary shears which trim both edges, cutting the material to the exact width and producing clean edges, which are essential for satisfactory welding. The external surface of the sheath is cleaned by high-speed rotary scratch brushes and the material is then passed to the first horizontal forming rolls.

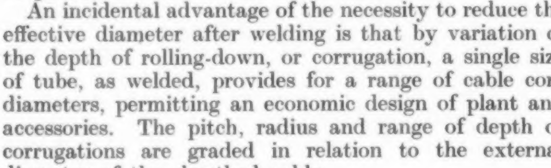


Fig. 3.—Tube closure rolls and welding unit.

The cable core is inserted at this point and the sheath progressively closed round it by five subsequent forming rolls, the last stage also acting as the seam closure roll for welding. Fig. 1 gives a general view of the machine.

The design of forming rolls adopted is illustrated in Fig. 2. This type of horizontal rolls controls and forms the strip without damage to the butting edges, the surfaces of which have been perfectly prepared for welding at the previous stage, and immediately after welding the sheathed cable passes through horizontal positioning rolls and torsion check rolls which correct any tendency for the sheath to rotate and so displace the weld seam in relation to the arc. All the rolls except the last-mentioned are driven through gears from a common shaft and provide the necessary motive power for the passage through the forming, welding and corrugating heads.

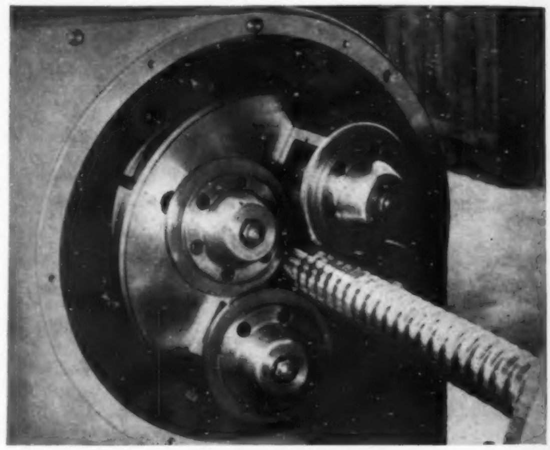


Fig. 4.—The corrugating head.

Welding.—The formed and closed strip passes under the argon arc welding torch which is mounted vertically above the closed sheath seam, and is attached to a compound slide which allows transverse movement for regulating the arc to the weld seam position, and longitudinal movement for advancing the torch along the seam for restarting the weld (Fig. 3).

The G.E.C. twin-arc welding process was finally adopted as being capable of giving optimum weld contour and of allowing variation of width of weld to suit any particular conditions. This system of welding uses a twin-electrode argon arc welding torch fed from a three- to two-phase. Scott-connected transformer and draws balanced current from the supply. A high-frequency spark discharge unit is included which serves to start the alternating current for welding. The use of this spark discharge allows the arc to be struck without the tungsten electrodes coming into contact with the work.

Protection of The Dielectric.—In order to avoid contact between the cable core and the bead of molten metal under the weld with resultant damage to the insulation

and liberation of gases harmful to the weld, several methods of protection were investigated. The one finally adopted employs a shaped metal shoe as a backing strip interposed between the sheath and core, which may be water cooled, or used to supply inert gas to the underside of the weld.

Rolling Down.—Reduction of diameter by rolling down is achieved by passing the formed and welded tube through a planetary roll system incorporating four curved-tapered rolls of deep section driven at a fairly high speed. A useful range of cable diameters may be covered by a single size of tube as formed and welded.

Corrugating.—The alternative method of diameter reduction by corrugation is put into effect by substituting for the set of four tapered rolls a radiused indenting roll and three thrust-opposing rolls driven at a predetermined speed in accordance with the pitch of corrugation required. The corrugating head is illustrated in Fig. 4.

Strip Joining.—Although aluminium strip is available commercially in continuous lengths adequate for most of the normal types of underground cable, complete freedom from limitation of production length in manufacture, and the ability to join random lengths of strip, are both extremely valuable assets.

The technique of cross-joining strip by welding was therefore worked out at an early stage of the development and follows the same general principles as the welding of the longitudinal seam, except that single-phase A.C. is used with a single tungsten electrode, the arc traversing the butting edges of the strip ends, which are cut obliquely so that opposite end portions do not coincide when the joined strip is formed into tube. The strength of the joint, which after peening is practically

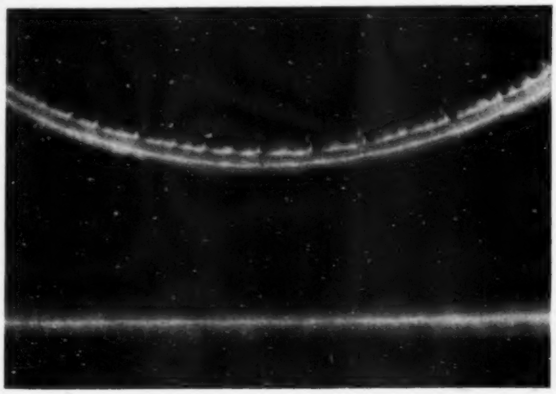


Fig. 5.—Rolled-down sheath after bend test.

flush, is almost equal to that of the parent metal. The position of a joint is hardly distinguishable in a subsequently formed and welded tube.

Mechanical Performance of the Welded Sheath

Bending Tests. (*a*) *Cylindrical Type.*—It is generally accepted that the bend test specified in British Standard No. 480 : 1942 (six bends on a drum of diameter 12*D*, *D* being the overall diameter of the cable) applied to a plain cylindrical aluminium-sheathed cable produces sheath distortion such as might seriously injure the dielectric. Hence it has been agreed tentatively to increase the bend test diameter to 20*D* when testing

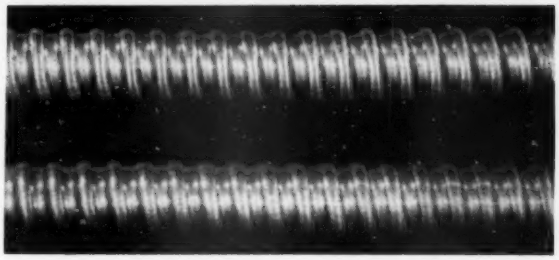


Fig. 6.—Corrugated sheath before and after bend-test.

such cables, and under these conditions the new welded cylindrical type of sheath manufactured by the rolling-down process behaves more satisfactorily than existing types of " drawn down " aluminium sheath. Fig. 5 shows a tested sample, subjected to three reverse bends at 20*D*, in the bent state and after re-straightening.

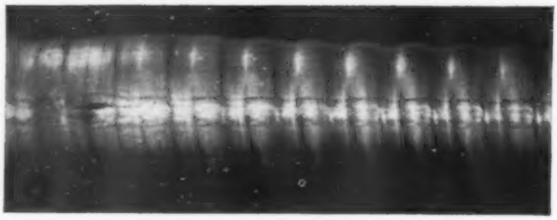
(*b*) *Corrugated Type.*—In formulating the design of the corrugated sheath the aim has been to equal or surpass the performance of lead-sheathed cable in respect of ability to withstand repeated bends on the actual diameters laid down in British Standard No. 480 : 1942. The relevant clause in this Standard is primarily concerned with the behaviour of the insulation on bending of the cable and does not make any reference to the condition of the metal sheath after the test, but it has been recognised in the course of this work that mechanical distortion of a metal sheath so much harder than the traditional lead sheath might cause injury to the insulation under the severe test conditions specified.

Hence it was decided that, after the appropriate unmodified bend test, the aluminium must not only be free from cracks but must show no excessive local distortion. The depth, radius and pitch of the corrugations are based on this requirement. Fig. 6 illustrates the condition of a 1·6 in. diameter cable before and after performance of the B.S. 480 Bend Test (six bends on a drum of diameter 12*D*).

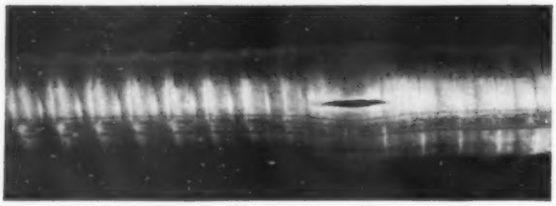
Weld Strength and Soundness.—The advanced designs of welding head and electrical system which have been previously described ensure standards of continuity and soundness in the weld comparable with those of an extruded sheath.

Fig. 7 shows the contour and microstructure of a weld in transverse cross section. The central fusion zone of the weld, on account of its greater thickness, is stronger than the parent metal, and the portions

Fig. 7.—Macrograph of transverse cross-section of weld. ×11



(a)



(b)

Fig. 8.—Bursting tests on corrugated sheath.

Fig. 9.—Hydraulic test apparatus.

adjacent to it are only slightly weaker than the remainder of the sheath wall. Hydraulic bursting tests at slow rates of strain may produce fracture at the weld boundary or at positions remote from the weld. Fig. 8a illustrates such a burst on a 2·7 in. diameter pipe of 0·098 in. wall thickness, which required about one minute under a pressure of 890 lb./sq. in. At 800 lb. per sq. in. a similar sample did not fail in 500 hours; when the pressure was raised to 900 lb./sq. in. the burst occurred in the parent metal (Fig. 8b).

Hydraulic testing equipment designed and constructed at the Research Laboratories for the investigation of bursting characteristics over an extremely wide range of accurately adjustable speeds is illustrated in Fig. 9, and the preliminary hydraulic tests on the corrugated type of sheath have already shown that it has adequate strength to function satisfactorily in any of the accepted types of oil filled or gas pressure cable without external metallic reinforcement.

Field Installations

Argon-arc welded aluminium-sheathed cable has been used in the important new distribution systems required for the recent extensions on the Company's Wembley Estate, including over 1,000 yards of 11,000 volt ring main cable. The bulk of these cables was buried direct, but there were also some difficult duct runs which were successfully negotiated, the work being greatly facilitated by the remarkable flexibility and lightness of the cables which were all of the corrugated type. Jointing presented no difficulty to men with normal experience in the handling of lead-covered cables. No special training was given apart from a demonstration of the "tinning" of the surface of aluminium with a proprietary tin-zinc alloy as a preliminary to plumbing with ordinary wiping solder. The accompanying photographs (Figs. 10 and 11) were taken during the installation work.

It may be stated in conclusion, that this new method of manufacture has brought into being a light metal-sheathed cable from which the prevailing disadvantages of this type, excessive stiffness and limitation in length, have been eliminated; that this has been effected in the case of the corrugated type with a greatly reduced consumption of aluminium per unit length of cable; that important modifications in high voltage cable construction, made possible by the resistance of the corrugated cable sheath to crushing and distortion during bending, offer the prospect of mechanically stronger high voltage underground power transmission lines at a cost lower than that of the equivalent lead-covered cable, and of any previously existing equivalent aluminium-sheathed cable.

Fig 10.—Demonstration of lightness of cable being installed on the Wembley Estate.

Fig. 11.—Illustration of the flexibility of the corrugated-sheathed cable.

Accident Prevention in the Iron and Steel Works of the U.S.A.

A Summary of a Report by A. Elson and P. Wright

(The United Steel Companies Limited, Sheffield)

Quite apart from the viewpoint of the individual concerned, the time lost to industry by accidents which could have been avoided justifies the adoption of all reasonable safety measures. Reference is made in this article to the methods of accident prevention used in American steel works where the accident rate is low.

TWO members of the United Steel Companies Limited—Mr. A. Elson, Accident Prevention Officer at the Samuel Fox and Company Branch, Stocksbridge, and Mr. P. Wright, Rolling Mills Superintendent at the Steel, Peech and Tozer Branch, Rotherham—spent six weeks in the United States earlier this year for the purpose of examining the methods adopted in American iron and steel works for the prevention of accidents. The plants visited were those in which the subject had been given special attention, and every facility was given to the investigators. On returning to this country, Messrs. Elson and Wright prepared a report on their visit and we are indebted to the United Steel Companies for making available a summary on which this article is based. In view of the importance of the subject, it is felt that much of the report will be of great interest not only to the iron and steel industry but to other productive groups in this country.

Effect of Legislation and Insurance on Accident Prevention

Legislation on accident prevention in the U.S. varies from State to State and has been built up on actual conditions existing in steel works. As a result of this, safety measures in the majority of works are in advance of legal requirements. In certain States, e.g., New York, Pennsylvania and California, legislation bears some resemblance to our Factories Act whilst in others it is far less comprehensive and stringent. In many States the office of factory inspector is a political appointment, the inspectors changing with the Government, and consequently they do not possess the knowledge of inspectors in this country; cases were quoted of factory inspectors visiting steel plants to learn their work. It follows, therefore, that legislation has little effect on accident prevention in the U.S.A.

As regards insurance, the majority of the firms are self-insured, an annual provision being made to meet possible liabilities arising from accidents. There is nothing comparable with our National Insurance (Industrial Injuries) Act.

Machine Guarding and Layout

The plants visited are amongst the best in the U.S.A., from the point of view of safety records, and whilst the standard of machine guarding at these plants is high it is not equal to that of the authors' Company. For example, although toothed gearing and shaft couplings are usually encased, the revolving shafts are unguarded. Nor was there seen any guarding of the long travel shafts on overhead cranes.

Owing to the amount of room available in most of the American steel works, machines are well spaced and wide gangways, adequate stacking and working areas are possible. Engineers' spares are invariably kept in one or two well defined areas outside production departments, and the standard of housekeeping is generally better than the average in this country. All of these things greatly reduce accident risks.

Personal Protection

Far more attention is paid to personal protection than in Britain. The wearing of safety boots, for example, is a condition of employment in most steel works, the boots being sold at cost price; payment is generally made by deductions from wages. There is little difficulty in persuading men to wear these boots, primarily because they are comparable in appearance, price and comfort with any ordinary boot on the American market and much better than their British counterparts.

Special gloves are provided and must be worn for work involving inherent risks. Many men wear ordinary industrial gloves even where no special hazards exist, but in such cases they are purchased by the workmen themselves.

The wearing of goggles is compulsory in occupations and sections of the works where there is a risk of eye injury. They are invariably worn by men working in machine shops, and at some plants by certain operatives in rolling mills and around blast furnaces. Eye protective equipment is issued free to the men who are required to wear it.

At several plants the men employed on the tapping of furnaces and the teeming of ingots are required to wear protective clothing, consisting of asbestos coats, trousers, gloves and wire mesh face shields, all of which is supplied free.

The wearing of hard hats—issued free—by men employed on work where there is a possibility of head injury is compulsory at most plants, with the result that they are worn by most maintenance men and furnace wrecking gangs.

The compulsory wearing of safety boots, goggles, protective clothing and hard hats undoubtedly plays an important part in reducing accident rates in American steel works. A certain amount of opposition was at first encountered when the wearing of protective clothing was made compulsory but this has now been generally overcome.

Organisation and Status of Safety Departments

In each of the steel works visited there is a safety department, and although the organisation varies, it

generally consists of an accident prevention officer (usually known as a safety director or safety supervisor) and a number of safety engineers and clerks. The accident prevention officer is equal in status to a departmental manager and is responsible either to the general manager himself or to the equivalent of a works manager.

The safety engineers are attached to sections of the works and often coke ovens and blast furnace departments, the melting shops, hot rolling mills, cold rolling mills, maintenance departments and miscellaneous departments each have their own. They are responsible to the accident prevention officer but work closely with departmental managers, helping and advising on all matters relating to safety. They are generally persons possessing initiative and drive, in some cases with university degrees, and they do not hesitate to stop and correct a man should they see him doing something that might possibly lead to an accident.

Responsibility for Accident Prevention

In every plant visited, responsibility for accident prevention rests ultimately on the foreman. He is, however, actively assisted in this part of his work by all levels of management, including the general manager, and by the accident prevention officer and his staff. If a man is injured the blame is attached, regardless of the circumstances, to the management and not to the man himself. A case was quoted of a departmental manager being suspended for several weeks for having a consistently high rate of accidents in his department. In another case, a foreman was relegated for " allowing " too many accidents to occur to his men. In one works, employing 21,000 men, great importance is placed on the accident record of his department or section when a manager or foreman is being considered for promotion.

As a rule, the general manager holds a monthly meeting with the works and departmental managers when the latter are called upon to give the reasons for any accidents — however small — which may have occurred, and to explain what steps they have taken to prevent recurrence. Works managers hold a monthly safety meeting with their departmental managers who in turn hold a monthly meeting with their foremen. Foremen meet all their men either in small groups, or as a whole, once a week. It should be noted that in the U.S.A. the foremen supervise considerably smaller groups than in iron and steel works in this country.

At several works all foremen are required to make " Job Safety Analyses " which consist of listing :—

(*a*) each step of every operation carried out in their department or section,

(*b*) the hazards connected with these operations, and

(*c*) the safety precautions or the procedure to be followed to eliminate the hazards.

This obviously involves a considerable amount of work and usually foremen are not required to complete more than one or two Safety Job Analyses per week. It is considered that the carrying out of these Job Safety Analyses exposes hazards which might well result in accidents.

Safety Propaganda and Publicity

At the entrance to nearly every works there are notice boards, in some cases as large as 12 feet square, showing by departments the accident records for the current month and the year to date.

Posters, larger but similar in detail to those in use in this country, are to be seen in prominent positions throughout most of the works, although warning notices and slogans painted on the walls of buildings are more in evidence. The responsibility for having warnings and slogans painted—they are normally changed once a year—rests with departmental managers.

Illustrated booklets, often of a humorous kind, giving advice on safety are from time to time handed to employees, and descriptions of how accidents have happened, with relative photographs, are circulated throughout the works and branches of firms.

There is a National Safety Council, on somewhat similar lines to our Royal Society for the Prevention of Accidents, which awards annually a plaque and banner to the steel works having the lowest accident frequency rate. These are displayed in a prominent position in the winning works and are very much coveted.

Financial Inducements

There are no real financial inducements in connection with accident prevention, although at one or two plants cigarettes and cigars are presented each month to the men of the department which has the lowest frequency rate in the works, or who create a record by working for the greatest number of man hours without a lost time accident. At one works the management used to present to the department having the best accident record a television set, a refrigerator or a washing machine for raffling but this gave rise to discontent and was stopped.

Safety Rules

The policy on the issuing of rule books varies ; some works have printed rule books for each department and trade. One plant has as many as 82 such books in addition to rule cards for individual jobs of work, others have one general rule book and special job sheets relating to particular operations.

In all the plants visited, discipline relating to unsafe acts and infringement of safety rules is enforced. It takes the form of verbal and written warnings, suspension and, in extreme cases, dismissal. Management is supported by the Trades Union in taking the appropriate disciplinary action.

Suspension is a real hardship as the average worker relies on a regular income to pay for his car, television set, refrigerator, washing machine, etc., which are commonly obtained on the hire purchase system, and there is no doubt that disciplinary action for infringement of safety rules helps to reduce the number of accidents in the steel works of the U.S.A.

First Aid and Medical Examination

Equipment in departments is limited to stretchers, blankets and tourniquets. No bandages or any other form of dressing are kept in departments since it is the general policy that any injury, however slight, should be treated only at the medical centre. Consequent upon this, the training of men in first aid is generally restricted to the movement of an injured person on to a stretcher, the carrying of stretchers, the control of bleeding and the performance of artificial respiration.

All new employees are examined by the works medical officer. As a rule, if a man is absent through injury, or through illness of more than five days, he must present

himself to the works medical officer for examination before recommencing work. There is no opposition to this rule.

Comparison of Accident Frequency Rates

In Britain, the accident frequency rate is usually calculated by the formula devised by the Royal Society for the Prevention of Accidents, and is expressed by the number of accidents causing absence from ordinary work for one or more days per 100,000 man hours worked. In this calculation accidents to, and man hours worked by, staff employees are excluded.

The American system is based on lost time accidents per 1,000,000 man hours worked and includes the figures for the staff, which amount to 15% to 20% of the total personnel, but the conception of a lost time accident is vastly different from ours. The keen competition to show the best accident records has led to the practice that if a man is injured steps are taken to find him alternative employment in order that his injury may not be counted as a statistical accident. As stated previously, there is no social welfare comparable with our National Insurance Acts and since absence from work entails serious financial loss by the sufferer, he gladly accepts alternative work. Another factor which may influence accident frequency rates is the usual practice of firms being self-insured.

Every effort was made by the authors to get figures of some reliability, and whilst it is impossible to generalise, because the practice in steel works varies considerably, it was found that the number of lost time accidents used in compiling the rate, because of post injury selective employment, was in many cases only a small percentage of the total that would be included in calculations here.

Allowing for this and for the inclusion of staff figures, as a rough approximation the overall frequency rate in the plants visited would be 1·65 if measured by our yardstick. The figures for the four iron and steel works of the authors' Company for 1951, which were the lowest ever recorded, ranged from 1·49 to 1·94 and for the whole Combine it was 1·78.

It should, however, be stressed that although British plants have achieved remarkable results during the last ten years there are no grounds for complacency. Allowing for all circumstances the figures are still inferior to those of several of the best works in the U.S.A. which have frequency rates of no more than 0·50.

Progress of the Scrap Drive

THE Home Scrap Drive was launched in January, 1951, by the British Iron and Steel Federation, in collaboration with the National Federation of Scrap Iron, Steel and Metal Merchants. The Drive has been intensified during 1952, supported by a personal appeal by the Minister of Supply, Mr. Duncan Sandys. The Drive operates through Joint District Scrap Drive Committees covering the whole of the U.K., the District Committees operating under a central Scrap Drive Committee at the Headquarters of the B.I.S.F. (Chairman: Capt. H. Leighton Davies, C.B.E.). Scrap surveyors work under each District Committee on the whole-time task of searching for ferrous scrap which, for one reason or another, is not being collected.

The figures for 1950, 1951 and 1952 (annual rate based on 42 weeks January/18th October) show that the receipts of scrap from home sources (other than shipbreaking) have exceeded the 1951 deliveries by more than 300,000 tons per annum, mainly due to the Scrap Drive and the effect of an increase in prices, which operated from August, 1951.

Personal visits have been made to industrial users of steel who have been urged to scrap obsolete plant and equipment. Within the steel industry itself 325,000 additional tons resulted from a special drive last year, and receipts from this source during the current year have been at an annual rate of 275,000 tons. Household scrap drives in search of obsolete mangles, fire grates and bedsteads have been held in many towns, and local authorities have been asked to segregate old tins and ferrous scrap from household refuse. Arrangements have been made with many local authorities to uplift disused tram track, and it is expected that some 50,000 tons will be obtained over the next twelve to eighteen months. The National Farmers' Union have supported a special direct appeal to over 200,000 farmers and instructions have been issued by the Service Departments for the acceleration of scrap disposal. Nor are the nationalised undertakings holding back—they are all co-operating in the campaign.

Imports of scrap during 1952 are at about the same level as last year, and in view of the increased home requirements of German works, there appears to be no possibility in the immediate future of obtaining additional supplies from overseas.

In a recent address to the National Federation of Scrap Iron, Steel and Metal Merchants, the Minister of Supply expressed his satisfaction at the substantial increase in receipts of scrap from home sources achieved during the current year, but emphasized the importance of scrap in maintaining steel production, and urged all concerned to continue their efforts. Steel-makers feel there should be no relaxation in the drive for scrap over the next few months: indeed the Scrap Survey and Drive must continue into 1953.

Furnace Company Expands

BUILDING work has now begun on a site adjoining the Birlec main offices and works at Tyburn Road, Erdington, Birmingham. These extensions will provide additional drawing office capacity and other facilities, whilst similar work at the other end of the factory will lengthen the existing works bays. These developments will enable the Company to provide even better service to its many customers and also help it to keep pace with its increasing volume of business. This constructional work is part of a larger project, the complete realisation of which is, however, delayed by current building restrictions.

Foundry Services (Canada) Ltd.

FOUNDRY SERVICES (CANADA) LTD. are now operating from their newly-built plant at Guelph, Ontario, Canada, where a considerable range of Foseco products are being manufactured. Their new address is 201–207 Alice Street, Guelph, Ontario.

Productivity in Steelmaking

B.I.S.R.A. Conference Discusses Team's Report

The Report of the Productivity Team which visited the United States in 1951 to study the American Iron and Steel Industry was published earlier this year. The recommendations made are to be discussed at a series of technical conferences, and at the first of these, held recently under the auspices of the British Iron and Steel Research Association, the steelmaking section of the Report was considered. A brief account is presented here.

THE recommendations made in the Report of the Iron and Steel Productivity Team are to be thrashed out in a series of technical conferences organised by the British Iron and Steel Research Association, by the Iron and Steel Institute and by local metallurgical societies. This procedure is being followed at the request of the three bodies to whom the report was presented: the British Iron and Steel Federation, the Iron and Steel Trades Confederation and the National Union of Blastfurnacemen.

The first of these conferences was held by B.I.S.R.A. at Ashorne Hill on October 1st and 2nd, to discuss the Report's observations and recommendations on steelmaking. DR. T. P. COLCLOUGH (British Iron and Steel Federation) was in the Chair, assisted by MR. R. W. EVANS (Steel Company of Wales, Ltd.). There were 114 delegates to the Conference (excluding B.I.S.R.A. staff) from 35 steelmaking companies, representing over 90% of the open-hearth steelmaking capacity of Great Britain.

Discussions were opened by three members of the Productivity Team. SIR CHARLES GOODEVE, the leader, introduced the Report and spoke on "The Size of British Steelworks: Recommendations for the Future"; DR. D. F. MARSHALL of the Park Gate Iron and Steel Co. Ltd., spoke on "Open-Hearth Productivity and Fuel Consumption: Main Factors Calling for Action"; and MR. D. KILBY, Colvilles, Ltd., on "Open-Hearth Practice in America: Possible Applications to British Practice" and on "Furnace Availability." A summary of the proceedings is presented in the following pages.

The keynote of the Conference was set by Sir Charles Goodeve, in his introduction, when he said that the hard fact that emerged from the report was that productivity in the U.S.A., whether measured by man hours or by furnace productivity, was higher than in the U.K. by a factor of two. This presented a serious and stimulating challenge to the steel industry of Great Britain and to this Conference in particular.

In considering furnace productivity, which was the key to the problem and from which other productivity measurements could be derived, only the basic open-hearth process was examined because it accounted for the great majority of steel production in both countries. This was divided into cold and hot metal practice, the latter being sub-divided into three categories: the duplexing methods peculiar to the U.S.A.; tilting furnaces with heavy slags peculiar to Great Britain; and the remaining hot metal fixed furnaces which formed the bulk of the capacity in each country.

The Report showed that there was a variation in furnace size between and within the two countries. On an average, cold metal furnaces in the U.S.A. were larger than those in the U.K. by a factor of 1·35, and cold metal furnaces represented 43% of U.K. capacity compared with 9% of U.S.A. capacity. Hot metal fixed furnaces in the U.S.A. were on an average 1·4 times the size of those in the U.K. and accounted for 77% of total capacity against 34% of that of the United Kingdom. In the U.S.A. 13% of the capacity was hot metal duplex, a process not normally used in the U.K. where 23% of steel was made in hot metal tilting furnaces. The overall average showed American furnaces to be 60 to 70% bigger than those in the U.K.

It was necessary to see whether it might be possible from the facts given in the Report to specify the optimum size of open-hearth furnaces. Several factors entered into this. Fuel, refractory and man hours consumption rates all favoured large furnaces. At Weirton in the U.S.A., for example, two 500-ton furnaces were each operated with only three men, though this, of course, involved the installation of machines for fettling and other tasks. One of the reasons why American productivity was greater was that each time a workman there pushed his control levers or tapped a furnace, a larger amount of material was moved. This, combined with lighter manning and the traditional higher driving rate, accounted for a very large part of the difference in productivity. It was true that large furnaces were more costly to build than small furnaces, but accurate figures on this point were difficult to obtain. Pro rata, the consumption of constructional materials should actually be less.

The Productivity Team had finally concluded that it was possible to recommend that all new basic open-hearth furnaces in this country should, as far as possible, not be smaller than those shown in Table I.

TABLE I.—RECOMMENDED SIZES OF BASIC OPEN-HEARTH FURNACES.

	Normal tons tapped	Furnace week productivity to be expected
Cold metal	150	2,000 tons
Hot metal		
Fixed (for low or moderate phosphorus)	200 to 250	3,000 tons
Tilting (for high phosphorus)..	300 to 400	3,000 tons

It was also possible to lay down the minimum number of furnaces desirable in a melting shop to give an even flow of steel to the rolling mills. In the U.K. the minimum number was probably six furnaces, except where large tilting furnaces were used, when three or four might be appropriate.

This led to the conclusion that the minimum size of an integrated works in the U.K. should be that which would give an output of 750,000 to 1,000,000 tons of steel per year. He thought that this was not going too

far, as in the U.S.A. there were primary mills with a throughput of 2·2 million tons per year.

Shop and Furnace Size

In discussing these points, most speakers accepted that the minimum figure of six open-hearth furnaces to service a rolling mill was justified. It is, indeed, a recommendation that has generally been put into effect already. Fewer furnaces, larger in relation to mill capacity, giving relatively large "gulps" of metal, need a cushion of soaking pits, where a larger number of small furnaces giving more frequent and relatively small "gulps" can often almost do without soaking pits altogether.

It was also suggested that six furnaces was not only the minimum but also somewhere near the maximum number of furnaces for economic operation in one shop, if interference between different units and unwieldy multiplication of charging and shunting capacities were to be avoided. It was pointed out that the thirty open-hearth furnaces planned for the Fairless Works now building in the U.S.A. were split into three shops, each containing ten furnaces.

At the other end of the scale it was stressed that blast furnace capacity should, in general, exceed open hearth demand by a sufficient margin. One delegate spoke of seeing his mixers "going through the week with little more than a puddle in the bottom" since the continuous working week had increased the demands on his iron supply.

The question of smaller, specialised manufacturers was raised by some speakers. This country, it was claimed, would be wise to concentrate on higher-value products for which smaller units were more suitable. We must not be "bemused by American production of straightforward steel for straightforward purposes." To this, Sir Charles Goodeve replied that this was to say that the U.K. had only a "jobbing trade" and that production must be scaled down accordingly. The report had allowed for this to a necessary extent and American standards had been scaled down. It might be that in particular cases they had not been scaled down enough, but it was now accepted practice that a works producing, for example, steel for wire rod should also produce material for reinforcing bars and other similar products. He thought that we tended to divide our manufacture of given products between too many manufacturers, and that in the long run simplification of this industrial structure would pay for itself, quite apart from the scope it would give for larger manufacturing units. Even so, there would be a residue of specialised products to be manufactured in small quantities and he thought that this would always give scope for the small cold metal shops.

Metallurgical Load

In discussion on how far the productivity gap between American and British furnaces was a real one and could be lessened, much comment naturally turned on the lighter metallurgical load carried by American furnaces. With copious supplies of consistently low phosphorus iron and high grade oil or natural gas for fuel, they carry a far lighter slag than British furnaces. Where 20% and even 30% of slag is commonplace in Great Britain, 10% and 15% of slag is seldom exceeded in the U.S.A., with all the advantages this means in heat transfer to the steel bath and in refining time. Some speakers maintained that the difference to productivity from this factor might be as much as 25 to 33%, and that if British steelmakers could have consistent supplies of iron of even 1 to 1·2% phosphorus, productivity would be raised considerably. Most speakers, however, thought that the difference in productivity attributable to raw material supplies was more likely to be in the neighbourhood of 10%. Results from the operation of the 200-ton furnaces at the Abbey Works of the Steel Company of Wales were quoted to show that these furnaces, of predominantly American design and operating on the ordinary raw materials of British practice, were giving an average weekly output of over 2,800 tons per furnace with a fuel consumption of 19·47 gallons per ton. This was parallel with the best American practice despite the handicap of a high metallurgical load. The labour productivity at the Steel Company of Wales was 1·25 tons per man hour compared with the average figures quoted in the productivity report of 1·15 for the U.S.A. and 0·52 for the U.K.

Consideration of what British steelmakers might do under American conditions was rightly felt to be unrealistic. Discussion centred on what could be done to get the greatest advantage from the adoption of larger units and what measures could be taken to increase productivity from existing units.

More large tilting furnaces with suitable semi-active or active mixer ancillaries were seen as one contribution. Duplexing was also discussed, and it was pointed out that the best size of open hearth furnace for this process was not determined. The average time of a duplexed heat is 4½ hours and very large outputs can be achieved. But it is, generally speaking, only economic if, as the Report states, the price of iron is not much higher than that of scrap, and it was suggested that the reason why duplexing is not more widely used in this country is economic rather than technical. Even so, one large open-hearth melting shop in the North Eastern area is being equipped with acid converters for duplexing.

In this connection, one speaker suggested that the basic Bessemer process itself might be more economic than the large open-hearth furnaces—either fixed or tilting—where iron quality was beyond a critical value, in spite of the larger iron losses inherent in the process. The so-called turbo-hearth process and its offshoots with oxygen-enriched blast could decrease this disadvantage.

Increased productivity of existing plant was, however, the chief preoccupation of most speakers in the discussion. Successful practice at the Abbey Works was described as partly due to adoption of American methods of charging by ground charger from stage bogies. It was possible to charge the 269 tons (112 tons of scrap, 112 tons of hot metal, 25 tons lime, 20 tons ore) in three hours. Single flow checkers with top temperatures of 1,250° to 1,400° C. were used and it was felt that air preheat was a cardinal factor in both production and economy. Fuel practice was to burn 525 gallons per hour until the charging of the hot metal was completed, the furnace being operated on an air fuel ratio control with 10% excess air, and a pressure control of 0·1 in. positive water gauge. On charging the hot metal, fuel feed was reduced to 250 gallons per hour, with 25% excess air, and later to 150 gallons per hour. Hearths were well insulated and had retained heat a fortnight after the furnace had gone off. There were two roof temperature pyrometers and the temperature was kept

at 1,650° C. by manual control. Roof life to the first patch (at the back of the furnace) was seven weeks, and the patch was installed in eight hours ; this lasted three or four weeks before another was installed which lasted another thirteen weeks. Refractory consumption was of the order of 25 to 30 lb. per ton. Warming up practice was not as fast as in America but was faster than that common in this country. From dead cold to first charge the normal at Abbey Works was forty hours.

Charging Rates

The Conference generally agreed that there was much room for improvement in the design of melting shops to obtain quick charging rates ; in fact more improvement could be gained here than from the design of furnaces. One speaker gave as an example his own shop where overhaul of charging facilities, which had been severely strained during the war, had increased productivity by 30%.

In the U.S.A., charging times are considerably better than the majority of those in this country. American pans frequently hold two to three tons ; large batches are fed to the furnace in spite of the danger of roof damage. The good packing of charging boxes at Sparrows Point had been observed by one member of the team who thought that there was a great deal that could be done in this country in this direction. The Americans employed extra labour in their scrap yards for this purpose, and he thought the money was well spent, both because it increased scrap density in the pans and, by neat packing, saved damage to the furnace.

It was suggested during the discussion that in this country better scrap preparation could be demanded both from scrap merchants and from steelworks mills, where there was often room for better sorting at the finishing end. If care were taken in packing a uniform proportion of light to heavy scrap, it would make possible the standardisation of pan and bogie weights. While we could not make our charging boxes as large as those used in the very large furnaces in the U.S., we could sometimes improve what we were using, especially by building larger doors into our furnaces, by the use of archless doors and other means. Larger magnets (the Americans use 65-in. magnets) could contribute to better and speedier scrap packing.

During the charging into the furnace the amount of fuel should be limited only by roof temperature which, with roof pressure control, gave the Americans good charging conditions as well as good fuel figures.

While good results are being obtained from the use of ground chargers and bogies on the melting stage in the American manner, this does not mean that rotating chargers impose delay. Time studies of shops using rotating chargers have sometimes shown that their effectiveness can be increased by as much as 50% without any change in their design. Indeed it was suggested that the free ground space made available by rotating chargers permitted much more extensive installation of mechanical aids.

Fuel Consumption

The American practice of using double burners in the open-hearth furnace was thought by some speakers to offer possibilities in the U.K. Many American furnaces have (*a*) two burners mounted in the end wall at 5 ft. 9 in. centres using both burners throughout the charge ; (*b*) two burners in the same vertical plane ; or (*c*) two as in (*a*) but with a third centrally mounted 9 in. above the other two. In this case the two lower burners are cut down after charging is completed. It was pointed out that, theoretically, so long as the burners were at least 5 ft. apart, they could burn 40% more fuel in a given total flame length than a single burner ; three burners could burn 70% more. This assumed that air could have unrestricted access to the flames. If the distance between them was less than 5 ft. they would act as a large single burner, which, given higher steam/oil ratios could burn the same amount of fuel as the two but with a flame of lower emissivity.

Another common practice in the U.S.A. was increasing the number of jets in a burner tube or using two or more tubes in one burner. One furnace had been seen in which four alternative fuels could be changed over quickly and easily. Where charging facilities were good, the devices which split up the fuel stream appeared to give an increased productivity of about 5%.

In discussing how far the process of increasing the number of burners and the heat input could go, the question was raised whether the single uptake furnace was used in America to this end. It was agreed that the single uptake could help, but it was felt that American experiments with it had not been uniformly successful and that we in this country were ahead in matters of furnace design. This also applied to control of fuel input by roof temperature though many Americans used fuel flow stabilisation which was less common over here.

The role which flame radiation research could play in securing the best value from fuel was also discussed. It was pointed out that some of the results obtained from the international project at Ijmuiden had already been used in work on burner design and work showing the best steam pressures for oil atomisation was also proving successful.

Refractories

Perhaps the most important difference between American and British practice in the use of refractories is the attitude to roof life. In the U.S.A. the life of the open-hearth roof is not considered to affect the producing power or availability of the furnace to a major extent. The roof can be replaced in a very short time as compared with the time required to replace other parts. The roof, in fact, has to adapt itself to the production tempo of the rest of the furnace and this frequently means that by the end of its life a furnace roof will have undergone well over 100% of patching.

American refractory consumption figures are low compared with those of the U.K., partly due to larger furnaces with a lower metallurgical load and partly due to the better refractory raw materials available. The possibility was mentioned that in this country low-alumina silica bricks might close the gap to some extent, both directly and by encouraging manufacturers of other refractories to reduce their alumina contents. It was said that if we could get an average porosity of 22%, production could be increased by 10%.

The zebra type of roof construction was common in America and claims of increased production up to 20% had been made. One British speaker had had one which lasted for twenty weeks. At the end of ten weeks the magnesite bricks were standing " proud," but after that they spalled and finished thinner than the silica

bricks. On the whole it was felt that there were possibilities in the zebra construction which might lead to greater production in this country. Advantages had been gained in both countries from basic ends, but it was clear that all-basic furnaces in this country were far more successful than they were in the United States. It was felt that these furnaces, which had proved themselves economic on the Continent where conditions were apparently less favourable, offered still greater possibilities here.

Open Hearth Furnaces: Design and Operation

There is little difference between normal designs of American and British furnaces, though American furnaces are considerably larger on the average. The study of furnace design according to fundamental aerodynamic principles is undoubtedly further advanced in the U.K.

A typical American 200-ton fixed furnace working the hot metal process and using oil fuel has a flat roof and only slightly sloping ramps. A gas-fired furnace has a steeper ramp with a pronounced knuckle. Extensive water cooling is used in doors, lintels, front skewbacks and buckstays. Uptakes and slag pockets are large. One departure from British practice is the frequent use of a 2-pass checker arrangement which is stated to give an air preheat of 1,350° C. or more and to work very well.

Checkers are usually constructed with three or four rows of cleaning holes through which steam cleaning lances are used at regular intervals of one to two weeks. (It was commented in the discussion that both 2-pass checkers and air blowing of checkers had been in use in this country respectively in 1930 and 1938.)

In the operation of the furnace in America it was noticeable that oxygen was perhaps losing its popularity as an aid to quick refining. It was more general now to use sinter instead of either ore or scale as bath feed, to overcome the high silicon content of the Mesabi ores.

In general, it was felt that U.K. practice with regard to immersion pyrometry and slag control was as advanced, if not more so than in the U.S.A.

American taphole and fettling practice both contained features of interest. It was sometimes found convenient to blow oxygen at the inside of the taphole on tapping to get better results than the more usual practice of blowing from the outside. The Americans appeared to use more magnesite round their tapholes which gave better results than tarred dolomite, though here the economic factor might be important.

In fettling it was noticeable that the Americans prepared very thoroughly for the operation. Dolomite was frequently delivered from the makers in large containers which could be handled on to the stage by cranes or it was brought on to the stage by hopper wagons and loaded straight into the fettling machines (which are universal American practice except on small furnaces). Raw dolomite appeared to be used for banks and magnesite for the hearths. A very noticeable feature was that the Americans fettled "hot," that is, with the fuel on. This provoked a number of comments in the discussion and it was generally felt that the general re-adoption of hot fettling in this country might save half an hour or more per charge. In some plants it had been given up during the war for various reasons and the initiative in getting back to it was felt to lie with the melters themselves. In fettling, as in taphole practice, some speakers thought that magnesite might show considerable advantage, even reducing fettling by 25 to 50%. Here again, however, the cost factor was important. Another feature of American practice that called for comment was their tendency to go for more frequent reversals and a quicker reversal time. Eight and ten minute periods with six or ten seconds for the actual reversal are common.

Slag Flushing

Since it is Great Britain's misfortune to have to operate fixed hot metal open-hearth furnaces with a heavy slag load, it is logical to examine the most elementary way of getting rid of part of it—by flushing. This is common practice in the U.S.A., but has the disadvantage that it causes some metal loss, and the oxide content of the slag may vary considerably. Several speakers pointed out that to operate the process while using iron from some of our indigenous ores would mean losing a greater proportion of iron in the flush slag than was being quarried in the ore. However, several works are flushing slags successfully from fixed hot metal furnaces in this country, and it is felt to be a subject that would repay further study.

Casting and Moulds

Larger moulds and nozzles are usual in U.S. practice than in the U.K. For the same size of ingot a nozzle six times greater than that normal in this country might be used. Bottle tops are widely used in the U.S.A., as they have been in Great Britain off and on for many years, for the sake of their higher yields, in spite of the danger of bad ingot surfaces that they entail. Tall moulds are also quite common.

Ingot mould life is less in the U.S. than it is here. Graphite is the most popular mould wash but in a number of plants the use of mould washes has been abandoned.

It was suggested that this country could reap considerable benefit in productivity if mills could be persuaded to take larger ingots, which would assist in reducing the delay between melting shop and mill because of the smaller number of ingots to be handled.

The H man Element

Manning on American steelmaking furnaces is 15% lighter on the average than it is in the U.K. Only three men work on one open-hearth furnace whatever its size. One particular feature of American labour, particularly in the casting pit, is its flexibility. There is very little "typing" of a man to a particular job. It was felt that we had something to learn from America on job evaluation and the arrival at an economic measure of what the job was worth. We might also reap advantage from keeping operatives more fully "in the picture" regarding the high value of the commodities and structures that they were handling. Better communication in general by means of telephone, teleautograph and pneumatic tube, for example, between the laboratory and the melting stage, was also a point that might be considered in many works.

Driving the Furnace

One of the most striking differences between American and British practice revealed in the report is the fact that cold metal furnaces in the United States are driven 33% faster than those here, the "driving rate" being

taken as taps per week. Part of the difference is probably accounted for by differences in the qualities of cold pig iron and fuel. A further part is due to the fact that in Britain many cold metal shops operate nineteen shifts per week, which means a direct loss of 10% in the driving rate compared with American furnaces.

The average driving rate of hot metal fixed furnaces in this country is only very slightly below (0·08%) the average rate in the United States. Contributors to the discussion, nevertheless, felt that our target must be 16 to 17 taps per week for almost all shops. One speaker said that when he was told that a furnace was "easily" reaching its allotted driving rate he immediately knew that its sights were set too low.

It was suggested that more frequent hot patching might make harder driving possible, and the time lost by cold fettling, previously referred to, also has an effect.

B.I.S.R.A. has been working for some time, by means of questionnaires, etc., on using available statistics for comparing driving rates and outputs in different works. A report now issued to all steelmaking members of B.I.S.R.A. gives the productivity and driving rate figures of all furnaces in this country for 1951, compared with figures for 1950 given in the Productivity Report. Firms are "coded" and each firm knows its position in this anonymous league table and can act accordingly. It is intended to issue this information annually. It is interesting that if driving rate is plotted against size of furnace, there is no correlation whatever. There is also a wide scatter with the categories of furnace so that differences cannot all be explained by raw material qualities and other uncontrollable factors. Indeed some of the highest driving rates come from some of the oldest plants.

Furnace Availability

While 91% of the open-hearth furnaces in America may be expected on an average to be operating at any one time throughout the year, only about 80% can be expected to be operating in this country. In some American works availability reaches 96 to 97%.

Measures which can be taken to secure high availability are twofold: (1) those that are taken to make the furnace last longer, (2) those taken to speed up repair time.

Water cooling, blowing out of checkers, combustion control, constant checking to eliminate premature failure (for example on the ramps), the use of zebra roofs, the use of chrome magnesite bricks from slag pocket to uptake to cut down wear and heat loss, the use of basic ends so that only the central portion of the roof need be rebuilt on repair—all these factors contribute to the American effort to secure the longest possible lives from their hard-driven furnaces.

As soon as the furnace goes down for repair, it is a primary objective on everybody's part to get it back into operation again. Design on ancillaries is also directed to this aim. The brick shed is placed at stage level, for example, so that mobile vehicles can come to the furnaces and even into them. There is plenty of room to get at the valve pit; the bottom of the slag pocket is level with the casting pit and large enough to admit tracked vehicles. At one works the slag pocket wickets run the whole length of the slag pocket and can be hinged upwards. The slag is normally removed from here within eight hours. Scaffolds are set at convenient heights to linings and roofs, and high-lift bogies, which do not impede the flow of metal, bring equipment to the repair workers.

Generally, there are three categories of repair in the U.S.A.: (1) quick roof and lining repairs, taking about 24 to 48 hours; (2) roof, furnace ends, linings and slag removal with cleaning of the flues, which take about three days; and (3) repair of roof, furnace ends, linings, slag removal, flue cleaning and removal of checkers, which takes five to seven days.

An important aspect of the speed with which these repairs are carried out is the clean design of the casting pit where, as only teeming is carried out, there is room to provide access to the slag pockets to tracked vehicles. Mechanical aids are used wherever possible.

There are several British firms which spend as little time in repairs as do American firms. For the most part, however, this is a field of endeavour where some of the best results can be achieved.

Blast Furnace Contract

HEAD WRIGHTSON AND CO. LTD. announce that they have been awarded a contract by John Summers and Sons Ltd., Shotton, Chester, for doubling the pig iron output of the plant at present under construction. Head Wrightson are at present completing construction of a plant at Shotton for the anticipated production of approximately 1,000 tons of pig iron per day. This integrated plant covers the entire range of iron making equipment from ore unloading, crushing and screening through sintering to a complete blast furnace plant with gas cleaning equipment and special rolling stock. The new furnace plant will be a duplicate of the one nearing completion, which is the largest blast furnace outside the U.S.A.

Largest Arc Furnace in Great Britain

BIRLEC LTD. of Erdington, Birmingham, announce that they have been commissioned by Samuel Fox and Co. Ltd., in association with The United Steel Companies Ltd., to supply the largest arc melting furnace to be either manufactured or installed in Great Britain. This Birlec Lectromelt equipment will have a nominal capacity of 60 tons and will be rated at 15,000 kVA with on-load tap-change gear. Samuel Fox will instal this unit at their Stocksbridge Works, where it will be used for the production of high quality alloy steel ingots. It is probable that nowhere else in the world will such a large tonnage of this type of steel be produced from a single furnace.

Refresher Course on the Rarer Metals

THE annual refresher course of the Institution of Metallurgists was held at Ashorne Hill, near Leamington Spa, from October 31st to November 2nd. This year the metallurgy of the rarer metals was the central theme: uranium was dealt with by L. Rotherham; the platinum group by E. C. Rhodes; chromium and manganese by E. A. G. Liddiard; beryllium by B. A Scott; tantalum and niobium by J. C. Chaston; molybdenum by L. Northcott; tungsten by I. Jenkins; and titanium and zirconium by J. W. Rodgers. In due course, all the papers will be published and will be obtainable from the Offices of the Institution, 4, Grosvenor Gardens, London, S. W. 1.

Architectural Letters in Metallised Plastic

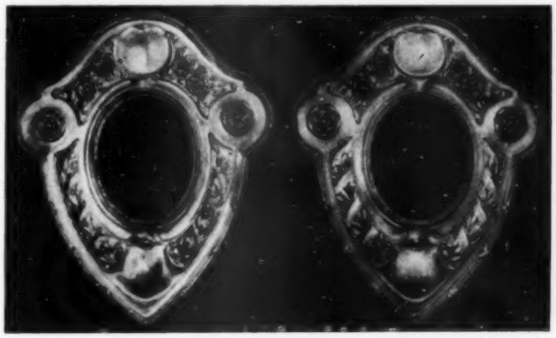
By D. McPherson

Shortages of conventional materials lead to attempts at substitutions which in most cases persist for the duration of the shortage. In developing metallised plastics for use in architectural lettering a manufacturing process resulted which is of importance in its own right.

A MANUFACTURING process of general interest to metal working concerns has been developed by J. R. Pearson (Birmingham) Ltd. Faced by serious restriction of their business by metal shortages, this firm has sponsored research into alternative manufacturing methods, and as a result has evolved a method of electroplating synthetic materials which appears to offer considerable scope for commercial development. The original idea was to devise some means of keeping an important section of the business ticking over until such a time as conditions returned to normal. However, the success achieved has established the metallising of synthetic materials as a manufacturing process in its own right, and one able to make an important contribution quite apart from, and uninfluenced by, the original consideration of shortages of essential metals.

The nature of the firm's interests decided that major attention should be focused on the thermo-setting plastics, and those materials which are within the scope of the process include phenol formaldehyde compositions—mouldings, castings, laminates, and impregnates such as asbestos and felts—and a number of urea formaldehyde products. The range of metallic finishes available comprises the orthodox electro-depositable metals, with commercial interest chiefly centred in chromium, nickel, tin-nickel, copper, brass, bronze, and the precious metals silver and gilt.

Within commercial limits, the size of the article to be treated is immaterial ; in fact, it is probably true to say that the larger the article the more pronounced the economy to be effected. However, the process is sufficiently flexible to accommodate a large number of components of all shapes and sizes without complicating the processing methods. It is not possible to give a comprehensive list of other applications to which this



Courtesy of J. R. Pearson (Birmingham), Ltd.

Plastic shield surrounds. The shield on the left has been chemically silvered only, whilst that on the right has been silvered and plated directly with cyanide silver. The dimensions are 15 in. × 11 in.

process might be applied, but those being explored include shields, coats of arms, motifs, display accessories, nameplates, badges, picture frames, knife handles, brush backs, automobile accessories, clock and instrument bodies, ornamental and souvenir brass, instrument gears and bearings and electrical components. One current application of more than passing interest, is in radar wave guides fabricated in laminated asbestos and selectively metallised in silver.

Courtesy of J. R. Pearson (Birmingham), Ltd.

Architectural letters and badges produced in metallised plastic. Finished silver—no electroplate. The large " O " is 14 in. × 10 in.

Principles of the Process

In operation, the technique is comparatively simple and does not involve elaborate equipment or technical supervision. The plastic components, whether they are mouldings, castings or fabricates, are, in most cases, of standard production quality. One point has become apparent, however: the quality of the surface leaves room for considerable improvement. As in all processes involving electroplating, good or bad initial surfaces exert a controlling influence throughout. It has been found cheaper and easier to correct before metallising than to endeavour, at a later stage, to polish out the accumulated effect of a bad starting surface. Where mouldings are destined for metallising, it pays to use superfinished moulds, thus ensuring maximum lustre on operative faces and, if necessary, to barrel polish or buff before metallising is commenced.

The critical part of any process designed for metallising synthetic materials lies in the conversion from a non-conductive to a conductive material. In the experimental stages of the process under discussion, it was soon apparent that failure at this stage inevitably led to failure of the finished article. The one factor which was found to over-ride all others was the nature of the primary conducting coat and its adhesion to the base plastic material. Conduction in itself is no problem at all. What proved so elusive for a long time was the anchoring

Courtesy of J. R. Pearson (Birmingham), Ltd.

A miscellaneous collection of letters in metallised plastic.

of the conductive coat to the plastic so that the inherent stress of subsequent electrodeposited coatings did not strip it from the underlay.

The answer to the problem was eventually located in a chemical diffusion process which, although very complicated from a physical chemistry viewpoint, proved to be quite simple to apply. By this means micro-films of metal can be developed at the surface of plastic materials so that they are virtually inseparable, except by harsh abrasion beyond the interface of union or by chemical solution. Some idea of the intimacy of the bond can be deduced from the fact that phenolic laminates one thirty-second of an inch thick, coated in this way, can be flexed and reflexed through the limits of elasticity of the laminate without showing deterioration in the adhesion of the metallic micro-film. Destructive heating tests show that adhesion is maintained up to the temperature of decomposition of the plastic, and in no case has it been found possible to strip the conducting film from the plastic by means of stresses inherent in electrodeposited coatings, whatever their thickness. It has been found possible to diffuse a number of metals—copper, silver, gold and others, but the metal nearest to the electrochemical and cost requirements for commercial operation is silver. The conducting films, unless specially required, are of an order of 0·0002 in. in thickness, and as there are no recovery or waste factors involved, coatings of this thickness can be produced quite cheaply.

Once the components are 'diffused' the electroplating can be pursued on fairly orthodox lines. It is customary and certainly desirable, to flash all parts with copper regardless of the finish desired. Acid copper is preferred, but if cyanide or Rochelle copper baths are used it is important to ensure that true cathode contact is made before the parts are immersed. Cyanide solutions are corrosive to silver, and as the silver coat is so thin there is little margin for error. Spotting or irregular strike can often be traced to solution of the micro-film before plating commences. The thickness of electroplate is determined largely by the function of the article treated. Heavy deposits are neither necessary nor advantageous unless the application of the article demands it. Thickness of electroplate will not prevent failure of an article if there is a weakness in the bond between plastic and conducting micro-film.

Finishing after electroplating is performed by standard methods, mopping, chemical colouring, bronzing, and lacquering being carried out as for the all-metal article.

Cast Synthetics

Reference has already been made to the interest in large components where the advantages of cost and metal saving are most marked. Most architectural letters are of a size which makes the cost of metal moulds for manufacture in plastic, prohibitive. Furthermore the number of letter designs, and the small quantities required, suggest at first sight that the larger article is outside the scope of such a process. By the use of cast synthetic resins, however, the short-run large article is the one which offers attractive economy over its all-metal counterpart.

In the early stages, the dimensional instability of phenol formaldehyde cast resins was a serious obstacle. Although a satisfactory bond could be obtained between conducting micro-film and resin, it was found that after electroplating the material contracted under the plate causing cracking of the deposit and also of the resin. In order to overcome this difficulty, a special resin had to be developed in which dimensional stability could be guaranteed. Resins of this nature are thermo-setting and, are readily cast into polivinyl chloride moulds. The moulds are prepared from master patterns and being resilient, allow considerable undercut in design to be incorporated without influence on the ejection of the casting from the mould. The moulds are used repeatedly and are inexpensive to manufacture. Reproduction of detail is extremely faithful and the finish of the casting directly related to the quality of finish on the pattern.

The castings can be machined, drilled and tapped, and polished to a high lustre. The preparation for metallising is similar to that involved in treating ordinary moulded articles, but the castings do show a superior surface due to the fact that they do not incorporate a large percentage of wood flour or other filler. The influence of this is most noticeable in the final stages when the components are spindle mopped prior to lacquering.

In conclusion, attention should be drawn to the fact that at the moment the plastic manufacturers have concentrated on producing plastics for use as such, and not materials which are destined to be electroplated. That a satisfactory method of metallising certain components is now available gives encouragement to the suggestion that, with the active co-operation of the plastic manufacturers, special purpose materials can be marketed which will make the metallising of plastic articles a very much more straightforward proposition.

The David Brown Companies

The David Brown Companies have recently acquired the first floor suite of 96, Piccadilly, London, W.1, as their new London headquarters. The present London Office Sales staff have been transferred from Bush House, London, W.C.2, to the new address. Telephone No.: GROsvenor 7747 (3 lines).

For the time being the London Office of David Brown Tractors Ltd., will remain at 49–50, Avenue Chambers, Vernon Place, Southampton Row, London, W.C.1, but this will be transferred about the end of the year. The actual date will be notified in due course.

Ultrasonic Soldering in the Foundry

Light Alloy Casting and Pattern Repairs

JUST over a year ago we published an article dealing with an efficient and effective method of soldering aluminium and its alloys without the use of flux. Before satisfactory soldering can be carried out, however, some means of removing the oxide film from the aluminium must be provided. In the method referred to, which was developed by Mullard, Ltd., oxide removal is effected by the use of ultrasonic vibrations, transmitted from a special soldering iron, through the molten solder, to the surface of the aluminium. The method is to-day finding an increasing number of commercial applications, and is helping to expand the scope and economic use of aluminium and its alloys in many branches of industry. A particularly interesting field of application is the foundry, where the Mullard Ultrasonic Soldering Iron is proving of great value for the surface treatment of faulty light-alloy castings and for the modification and repair of aluminium patterns.

Superficial Repairs to Light-Alloy Castings

The main causes for the rejection of light-alloy castings in foundries are blow-holes, dross inclusions and cracks. If these defects are severe, the cause of the trouble is diagnosed and rectified, and the faulty castings are returned to the melt. In practice, however, in spite of the care that is taken a number of light-alloy castings are rejected on account of surface blemishes, which, although not materially affecting the strength of the castings, nevertheless mar their appearance. The reclamation of such castings has for long been a pressing problem in the foundry.

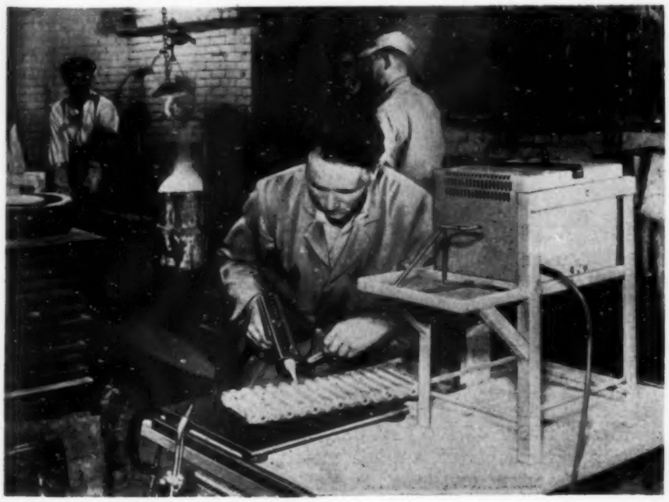
In the past, this problem has to some extent been overcome by filling in the surface defects with metallised glues or molten aluminium. The results, however, have never been entirely satisfactory and the repaired areas could often be detected, even after painting. With the aid of the ultrasonic soldering method however, surface blow-holes and cracks can now be quickly and permanently filled, and an excellent finish obtained. The great advantage of this new soldering technique is that a strong and permanent bond is obtained between the solder and the base metal. Moreover, tin-zinc solder is used which has a texture and colour similar to that of aluminium. This means that after machining the treated areas are almost indistinguishable from the surrounding parts of the casting.

The treatment of castings by the ultrasonic soldering method is quite simple. The casting is first preheated to the melting point of the solder used, and the cavity is then filled with molten solder and the bit of the soldering iron applied. The erosive action of the vibrating bit removes the oxide film on the sides and bottom of the hole, and rapid and effective tinning occurs; the bit is then withdrawn. If necessary, further solder can be added and allowed to solidify, after which the surface can be machined to the shape of the casting.

Although the ultrasonic soldering process is quite effective for the rectification of surface defects in

Right—Tinning an aluminium-alloy casting pattern in preparation for soldering on an additional part required to meet changes in production.

Below—Rectifying surface sand faults on an aluminium-alloy water cooling element.



castings, it cannot, however, be considered suitable for jointing castings where the design is such that appreciable stresses occur across the repaired break. The reason for this is that, although the zinc-base solder has a shear strength of 3 tons/sq. in., it is normally not as strong as the base metal. If, however, the part of the casting to be treated is used only for ornamentation, lap and butt joints can be used, as they will withstand all normal usage.

The Modification and Repair of Aluminium Patterns

Another promising application of the ultrasonic soldering technique is in the modification and repair of aluminium patterns. On account of their greater resistance to wear, there is a tendency in many foundries to use patterns of this kind in place of those of wood. Up to now, however, alterations to light metal patterns have presented serious difficulties. Some success has been obtained with the riveting and red lead method, but this tends to be costly and wasteful. Using the ultrasonic soldering iron, however, an initial tinning of the area to be modified or repaired can be effected on which solder can be built up and formed to shape. The saving in time over the fabrication of a new piece is thus considerable and the resultant part will withstand all normal usage.

Soft soldering can also, in many cases, be utilised in the manufacture of the initial light metal pattern. This can lead to a saving in machine shop capacity, for instead of drilling and tapping the various parts to be joined together, they can now be effectively soldered.

Technical Features of the Equipment

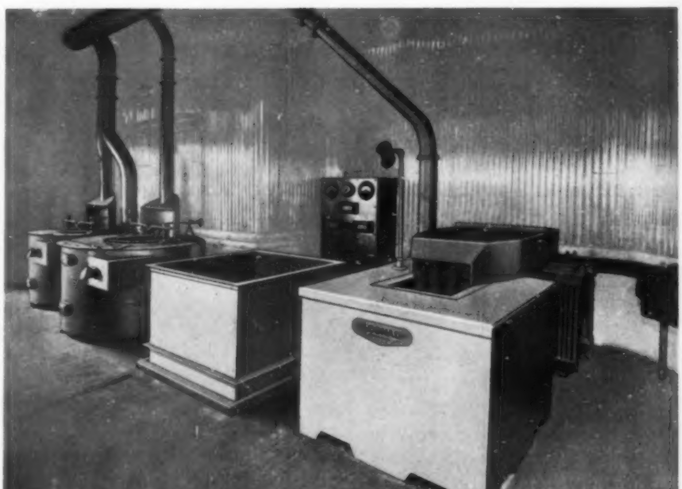
The ultrasonic soldering equipment for use in the foundry consists of two units; a soldering iron and a power unit. The soldering iron is supplied with a flat chisel bit for the treatment of large surfaces and a tapering bit for the treatment of cavities. Heating of the bit is by means of a low voltage resistance winding of conventional type, the necessary power being supplied from a transformer contained in the power unit.

The bit is secured to a magneto striction transducer, which converts the electrical energy from the power unit into mechanical vibratory energy, thus causing the tip of the bit to vibrate at a high frequency. The amplitude of vibration is very small, being in the region of fractions of a thousandth of an inch. A trigger switch in the handle of the iron controls the supply of ultrasonic power to the bit, and the heater element is controlled from the mains switch on the power unit.

Arrangements are being made for the Mullard Ultrasonic Soldering Equipment to be demonstrated in foundries in various parts of the country. Information regarding this, and further technical details relating to the equipment, can be obtained on request from the Equipment Division, Mullard Ltd.

Tool Room Heat Treatment Installation

A NEW heat treatment installation consisting mainly of salt baths for the treatment of tools and dies has recently been completed in the tool room heat treatment department of Reynolds Light Alloys, Ltd., at Redditch. The new plant, including the fume extraction equipment, has been supplied and installed by McDonald Furnaces, Ltd., and comprises a twin-chamber gas-fired salt bath, a gas-fired tempering salt-bath, and a high temperature electrode salt bath.



Twin chamber gas fired salt bath and electrode salt bath with pyrometer and electrical gear mounted on panel in background.

The twin-chamber salt bath is of special interest in that it is capable of operation in two different ways. In the first of these, only the primary bath which can be heated to 950° C. is fired, the adjacent chamber being heated by the waste gases from the main chamber to a temperature suitable for pre-heating the work before immersion in the high temperature bath. In this way a considerable proportion of the sensible heat of the waste gases is recovered. The occasion may arise when both baths are required at the high temperature, and in the second method of operation, the waste heat from the main chamber is supplemented by the use of secondary firing in what is normally the lower temperature chamber. Both units are designed with the burners arranged for tangential firing round the combustion chamber, thus effecting uniformity of heating and an increase in pot life due to the absence of flame inpingement. The burners are arranged for hand operation, but automatic control can easily be fitted if required.

The tempering bath is of similar construction to the furnaces already described, but operates at temperatures up to 650° C., while the electrode salt bath is used for hardening at temperatures up to 1,250° C. Of orthodox construction, this furnace has a maximum rating of 100 kW. and is provided with a tap-changing transformer, an Ardometer and a temperature checking pyrometer.

NEWS AND ANNOUNCEMENTS

Beilby Memorial Award, 1952

FROM the interest derived from the invested capital of the Sir George Beilby Memorial Fund, at intervals to be determined by the Administrators representing the Royal Institute of Chemistry, the Society of Chemical Industry and the Institute of Metals, awards are made to British investigators in science to mark appreciation of records of distinguished work. Preference is given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering and metallurgy, and awards are made, not on the result of any competition, but in recognition of continuous work of exceptional merit, bearing evidence of distinct advancement in science and practice.

In general, awards are not applicable to workers of established repute, but are granted as an encouragement to younger men who have done original independent work of exceptional merit over a period of years. The Administrators are empowered to make more than one award in a given year if work of sufficient merit by several candidates is brought to their notice. For 1951 two awards, each of one hundred guineas, were made to Dr. K. H. Jack and Dr. W. A. Wood.

Consideration will be given to the making of an award or awards from the Fund early in 1953. Outstanding work of the nature indicated may be brought to the notice of the Administrators, either by persons who desire to recommend the candidate or by the candidate himself, *not later than 31st December*, 1952, by letter addressed to the Convener of the Administrators, Sir George Beilby Memorial Fund, Royal Institute of Chemistry, 30, Russell Square, London, W.C.1. The letter should be accompanied by a short statement on the candidate's career (date of birth, education and experience, degrees and other qualifications, special awards, etc., with dates) and by *eight copies* of a list of references to papers or other works published by the candidate, independently or jointly.

The Exploitation of Low-Grade Ores

Study by O.E.E.C. Working Party

A WORKING party of European and American specialists, meeting in Paris at the headquarters of the Organisation for European Economic Co-operation, has completed a two-day study of methods which might lead to the exploitation of metallic or non-metallic low-grade minerals, that is, those that are marginal or whose complex nature makes them difficult to treat. This study is complementary to research already being undertaken on the conservation and substitution of scarce raw materials.

An exchange of information took place on the available resources in equipment and scientific personnel at the disposal of those European research laboratories which are likely to study this particular sector, and on the research at present in progress.

The information collected—which will be completed by supplementary data to be supplied by the representatives of the various countries who attended the meeting—will be assembled in a draft report for submission in due course to the Productivity and Applied Research Committee of O.E.E.C.

In the meantime, the experts unanimously agreed on the importance of certain basic research, as a greater knowledge of the chemical and physical processes involved in what is now regarded as the science of mineral dressing would in due course allow certain types of ores to be employed which are at present considered unusable. With a view to encouraging further research on certain particular subjects which the experts consider it would be most profitable to study, they have drawn up the following list of studies. They intend, in their report, to draw the attention of the Productivity and Applied Research Committee and of European scientific and technical circles to this list :—

(1) Mechanics of grinding.
(2) Classification of very fine sizes.
(3) Dense medium separation of fine sizes, i.e., smaller than 10 mesh or 1·5 mm.
(4) Flotation of oxides such as cassiterite, chromite, hematite, magnetite and pitchblende.
(5) Flotation of oxidised or weathered ores such as those of lead, zinc, copper and nickel.
(6) Influence of soluble salts in flotation.
(7) The beneficiation of slime by method of selective coagulation.
(8) Electrostatic separation having in view conditioning before separation.
(9) Pelletising.

The Institute of Metals

Students' Essay Competition

The Council of the Institute of Metals will present two prizes of twenty guineas each for the best essays submitted by Student Members of the Institute or Associate Members of Local Sections who are eligible for Student Membership of the Institute. Each prize will be in the form of ten guineas in money and ten guineas in scientific, technical or other appropriate types of books, to be selected by the prizewinner.

Further particulars of the regulations governing the competition can be obtained from The Secretary, The Institute of Metals, 4, Grosvenor Gardens, London, S.W.1, to whom entries must be submitted by January 1st, 1953.

British Productivity Council

THE British Productivity Council was formerly established on November 4th. The new organisation is on a broader basis than its predecessor, the U.K. Section of the Anglo-American Council on Productivity, whose work it is taking over as well as engaging in fresh activities.

In addition to representatives of the British Employers' Confederation, the Federation of British Industries and the Trades Union Congress—the constituent bodies of A.A.C.P. since its inception 3½ years ago—the Council includes representatives of the Association of British Chambers of Commerce, the National Union of Manufacturers and the nationalised industries. Each of the participating bodies will subscribe directly

to the funds of the Council. Subject to the approval of Parliament, a Government grant will also be available. Sir Peter Bennett was appointed Chairman of the Council at its first meeting in London, with Mr. Lincoln Evans as Deputy-Chairman.

The Council, whose aim will be to seek to engage the active interest of industry in the pursuit of high productivity, and to give it all possible help in its independent activities, will meet shortly to consider in detail the extent and nature of its future programme.

All communications for the British Productivity Council should be addressed to 21, Tothill Street, London, S.W.1 (Tel. Whitehall 1671).

Postgraduate Courses in Physical Metallurgy

The Postgraduate School of Physical Metallurgy in the University of Sheffield is organising a series of full-time courses designed primarily for metallurgists in industry to acquaint them with recent developments in physical metallurgy.

Course 2 on "Principles of Deformation" has already started at the time of going to press, but the remaining courses, on "The Formation and Properties of Alloys," "Internal Stresses, Recovery and Recrystallisation," and "The Solidification of Metals and Alloys," do not commence until early in 1953. Some vacancies still exist on these Courses and further particulars can be obtained from the Registrar, The University, St. George's Square, Sheffield, 1.

Attendances at the International Machine Tool Exhibition

An analysis of the figures of attendances at the International Machine Tool Exhibition reveals the following interesting facts :—

The attendance of potential buyers in response to direct invitations by exhibitors was 60,524 in 1952 as against 51,213 in 1948, an increase of 11·5%. Attendances by works parties and on admission tickets bought in advance increased to 15,439 from 14,826, an increase of 10·5%. There was a distinct falling off in attendances in response to the issue by the M.T.T.A. of complimentary tickets and seasons and by the attendance of the general public on payment at the door. The aggregate of these latter figures was 31,968 in 1952 as against 57,246 in 1948.

The Machine Tool Trades Association had it suggested to them in 1948 that they were missing an extremely large increased attendance on the part of the general public by not remaining open until, say 9 o'clock in the evening. It was felt, however, that the strain on exhibitors and their staffs and the denial of valuable opportunity for evening conferences and contacts with prospective customers, and especially friends from overseas, could not be incurred in order to attain this additional attendance. The same policy was followed this year and indeed the Exhibition closed half-an-hour earlier in 1952 than in 1948.

The significance of the figures of increased attendances referred to above is underlined by the reports, uniformly received from exhibitors, who say that the quality of the visitors to their stands, the solidness of enquiries and even the actual sales made exceeded their greatest expectations.

Personal News

Metropolitan-Vickers Electrical Co., Ltd., announces that on November 1st, 1952, Mr. W. A. Coates was appointed General Sales Manager and Mr. F. Gurney was appointed Manager Home Sales. Mr. Coates, who succeeds the late Mr. Duncan MacArthur, retains his seat on the Board.

The Directors of the Incandescent Heat Co., Ltd., the parent Company of the Incandescent Group of thermal engineering Companies, whose main works is at Smethwick, announce the appointment of Mr. Thomas Geoffrey Fallon as Managing Director and Mr. Cecil George Pettit, M.I.P.E., as Assistant Managing Director. The Chairmanship of the parent Company and the Group is held by Mr. John Fallon, J.P., M.I.Mech.E.

Mr. J. F. Willsher, formerly Production Controller of George Kent, Ltd., has been appointed Production Manager, responsible for both Material Control and Production Control.

Dr. A. J. Shaler has been appointed Professor of Metallurgy and Chief of the Division of Metallurgy at the Pennsylvania State College. Dr. Shaler, who has been on the staff of the Massachusetts Institute of Technology, first as Assistant Professor and later as Associate Professor, since 1947, was granted leave of absence from M.I.T. from September, 1950, until December, 1951, during which period he served as Scientific Liaison Officer with the Office of Naval Research, European Branch.

Mr. L. Atherton has recently joined the Equipment Division of Mullard, Ltd., to take charge of the Special Products Commercial Group which specialises in ultrasonic equipment and laboratory and industrial applications of electronic techniques. Mr. A. E. Crawford, of the Equipment Division, is now in charge of a special assignment to investigate applications of ultrasonic and other electronic equipment. He is undertaking this work at one of the Wandsworth factories of the Company.

Mr. Adam Dunlop has resigned from Messrs. Rolls Royce, Ltd., on his appointment as Technical Director of Messrs. Shaw Processes, Ltd., Newcastle-on-Tyne.

Mr. H. L. Bowen, a technical executive of the Valve Division of Mullard, Ltd., has recently completed his twenty-fifth year with the Company. To mark the occasion an informal luncheon was held recently at Frascati's Restaurant, London, when Mr. T. E. Goldup, a Director of Mullard, Ltd., presented Mr. Bowen with an inscribed gold watch and a cheque.

Lt.-Col. J. P. Hunt, Managing Director of the Hallamshire Steel and File Co., Ltd., and a Director of Shipmans (Sheffield), Ltd., has been appointed to the Board of the Midland Bank.

Mr. Alan P. Good has resigned his position as Managing Director of the Brush Electrical Engineering Co., Ltd., on account of ill-health, but will remain a Director and Deputy Chairman of the Company. Mr. M. Beevor, Deputy Managing Director, succeeds him as Managing Director, and Mr. I. T. Morrow becomes Deputy Managing Director.

Mr. P. Spear has been appointed Director of Research at the Research and Development Department of Rubery, Owen & Co., Ltd.

RECENT DEVELOPMENTS

MATERIALS : PROCESSES : EQUIPMENT

Argonarc Spot Welding Process

An interesting welding development has recently been introduced by the British Oxygen Co. Ltd. It is the Argonarc Spot Welding Process which meets the need for speedy flux-free spot welding on stainless steels and also for tack welding in assembly work. The proeess may also be used on bright mild steel and certain non-ferrous metals. One of the major advantages of the process is that access to one side of the work only is required and this makes possible the use of the equipment on joints which would be inaccessible to conventional spot welding equipment, and for on-site jobs where transportable apparatus is essential.

Whereas normal spot welding methods require a comparatively high current to raise the contact area to welding temperature, the Argonarc Spot Welding Torch uses heat from a low current arc struck between a tungsten electrode and the workpiece. Normal spot welding equipment is bulky and limited in scope since access to both sides of the job is necessary. The Argonarc equipment, on the other hand, is readily transportable, economical and achieves perfect fusion with access to the top sheet only, manual pressure being provided by the operator with the torch itself. This method of fusing the top sheet to its bottom counterpart gives the characteristic circular spot weld ; the arc, tungsten electrode and spot area are protected from the atmosphere by a shroud of argon gas. Automatic operation is provided by an electric timer unit which varies the time over a wide range—usually from 0·8 to 5 seconds, according to the type and thickness of material.

A particular advantage of the Argonarc process is its ability to join thin to thick sections. So long as the top sheet is not more than $\frac{1}{16}$ in. thick, the joining of sheet to sheet, sheet to angles, tees or bars, or any other joint calling for unequal thicknesses, can be satisfactorily made. The process is also suitable for tack welding butt joints in thin gauge sheets.

In operation, the current and arc time are adjusted to suit the type and thickness of material concerned and the torch is positioned over the point at which it is desired to make a weld. Pressure is exerted manually by the operator on the torch, thus bringing the parts to be joined into intimate contact. The trigger switch is actuated and the control then switches on in correct sequence the gas and cooling water supplies, followed by the H.F. current and the main welding power. This is held for the pre-set period, after which all supplies are cut off apart from the argon which is allowed to flow until the tungsten electrode has cooled. The torch is then lifted and the sequence of operations may be repeated.

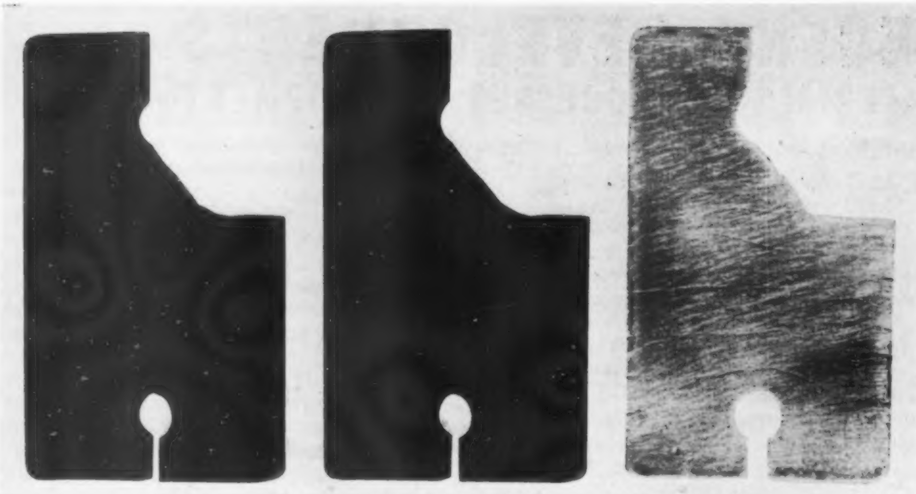
Since the arc is screened by the torch nozzle, the equipment may be used in any workshop without inconvenience to other personnel.

*The British Oxygen Co. Ltd., Bridgewater House, Cleveland Row, St. James', London, S.W.*1.

Fluorescent Magnetic Crack Detection

The detection of cracks in magnetisable materials by the magnetic powder method has been used for some 30 years. During that period there has naturally been a number of developments in both the means of applying the magnetic particles and in the methods of magnetisation. In the earliest methods the magnetic field was applied by means of an electromagnet, and subsequently longitudinal defects gave impetus to the development of magnetisation by means of the passage of an electric current through the part. The magnetic powder was originally used dry (and still is for certain applications), but it is now more usually suspended in paraffin or some other oil and used in the form of a bath or spray. In suspended form the magnetic fluid is often referred to as a magnetic ink, and in the earliest types the particles were black. This was quite satisfactory for use with machined surfaces where a good contrast was obtained. In the cases of black surfaces, such as the surfaces of rolled bars, forgings or heat-treated parts, there was insufficient contrast to show the cracks readily. This defect was overcome by painting the surface with some light coloured paint, such as aluminium paint, but a better solution was provided by the development of inks containing light coloured particles, red coming into common use during the last war. The red fluid is suitable for use on either black or machined surfaces, although some inspectors still prefer the black fluid for machined components.

The Manchester Oil Refinery, Ltd., have now produced a fluorescent, magnetic ink with the trade name of Lumor. This ink is a suspension of fluorescent, magnetic



(a) Steel plate as seen by ultra-violet light before the application of Lumor ink.

(b) The same plate after the application of the ink. Grinding cracks are shown clearly in full detail.

(c) The plate in white light after application of the ink. The grinding cracks are still visible but the contrast with the background is reduced.

(a) (b) (c)

material in a special liquid medium. The product represents a further advance in the technique of non-destructive testing, the flaw indication being viewed in ultra-violet light when the fluorescing deposit gives an enhanced contrast. This, it is claimed, reduces fatigue of the operator where the amount of inspection work is heavy and continuous.

The ink may be applied by pouring from a non-magnetic ladle, by brushing, by spraying or by dipping, and any of the normal methods of magnetising may be employed. An ultra-violet light source, with a black glass filter, is required in addition to the magnetising equipment, and for this purpose a Model 15 lamp made by Hanovia Limited has been found suitable. All the flaws are revealed instantaneously in a brilliant green fluorescing pattern, the picture being quite clear, as can be seen from the illustration. The fluorescence is clearly visible under shop lighting conditions.

Lumor ink is supplied in two grades, Lumor K with a petroleum base, and Lumor S, which has a non-petroleum base and is odourless. The latter can safely be used on rubber-bonded steel or cast iron.

The Manchester Oil Refinery, Ltd., Twining Road, Trafford Park, Manchester, 17.

Finishes for Brass, Bronze and Copper

THREE new finishes for brass, bronze and copper have been introduced recently by Metal Processes Ltd. There is no alteration in the size of an article as a result of treatment, and the surface finish is the same after treatment as it was before. If a polished finish is required, therefore, the article must be polished before treatment. Although it is not considered necessary, all finishes may be lacquered if required. All three processes use immersion in a warm solution and no skilled labour is required.

"*S.G.*" (*Steel Grey*) *Process.*—This is a process for imparting a protective finish to brass, phosphor bronze, copper, etc., by simple immersion in a warm aqueous solution of the appropriate chemicals. These are supplied in concentrated form for dilution with water before use. Components for treatment are placed in iron wire mesh baskets, degreased, swilled and immersed in the warm "S.G." solution for a few minutes, after which they are swilled in cold and hot water and dried. The treatment tank should be vitreous enamelled. The ultimate colour is Steel Bronze or Steel Grey. If, however, the immersion time is lessened, dark gilt, dark straw bronze, heliotrope and blue colours are easily and simply obtained at will. In these latter cases, according to requirements, they may subsequently be clear lacquered.

"*Blass*" *Process for Producing a Black Protective Finish on Brass.*—A black protective finish is given to brass by immersion for a few minutes in wire basket loads in the "Blass" process solution contained in a vitreous enamelled tank. The solution is supplied in liquid form, ready for use, and is heated to 110°–140° F. Components to be treated must be degreased and swilled before treatment, and afterwards swilled in cold and hot water and dried.

"*Blazic* 4" *Process for Producing a Black Protective Finish on Copper.*—The solution for this process is supplied in concentrated form for mixing with water before use. Treatment is carried out by immersion in the solution in a vitreous enamelled tank at a temperature of 95°–100° F. for a few minutes. The operation may be accelerated by increasing the temperature to 140° F., but in this case the colour may not be quite such a deep black. Before the final black colour is obtained, the components being treated acquire a series of iridescent and bronze colours, and any of these finishes may be retained by removing the articles from the process liquid, swilling and drying.

Metal Processes, Ltd., 758–786, *Kingsbury Road, Erdington, Birmingham*, 24.

"Metana" Aluminium Paste

IN a new factory at Crawley specifically laid down for the production of aluminium paste, Johnson & Bloy, Ltd., are now making "Metana" aluminium paste in a Standard grade for finishing paint and a Non-Leafing grade for priming and undercoatings. A Superfine grade will be added shortly for use in the specialised finishes.

CURRENT LITERATURE

Book Reviews

PERCIVAL NORTON JOHNSON

By Donald McDonald. Published by Johnson, Matthey and Co. Ltd. 30s.

We are inclined to overlook the part played by the early pioneers in the great industrial progress made in Great Britain during the last century; while it is necessary that we should be continually looking ahead, to keep in the forefront of progress, our indebtedness to early pioneers should cause us to reflect on the work and character of those who helped so much by laying the foundation for much that has since been accomplished. In this biography the author has presented a very interesting story of one of the pioneer metallurgists.

Percival Norton Johnson was born in 1792 in the City of London; his father, an assayer of ores and metals, was the only commercial practitioner of this profession in the City. Although little is known of Percival's early life, upbringing and education, there is no doubt that he was apprenticed to his father in the Worshipful Company of Goldsmiths and entered his business at the age of fourteen, and that he obtained the Freedom of the Company in 1814. In addition to his normal work, he must have studied considerably, for in 1812 he contributed an article to the *Philosophical Magazine* on experiments which proved platina, when combined with gold and silver, to be soluble in nitric acid. In a note appended to this paper he observed that palladium was such a general alloy of Brazilian gold as often to alter the colour; in a particular case a Brazilian bar contained nearly 20%, altering the colour almost to that of the metal palladium. It should be noted that palladium had only been discovered eight years before. Johnson made very profitable use of this observation some twenty years later.

At twenty-three Percival was very active and competent in the business and took over control, but shortly afterwards he established an independent business in premises adjoining his father's; in this way he was able to render occasional assistance his father needed. As a practical mineralogist he became a geological and mineralogical adviser to mining prospectors, and as there was a good deal of mining prospecting going on at that time Percival's business began to prosper and, in 1822, he leased new premises in Hatton Garden.

Percival was keenly interested in the metals of the platinum group, of which all except ruthenium were by that time known. He had dealt extensively in platinum in his father's business and his friendship with Thomas Cock, who was an expert in the preparation and fabrication of malleable platinum, gave him full knowledge of dealing with it. Cock brought other interests to Johnson, one being the vitreous colours used for the decoration of pottery and glass; another was the extraction of uranium oxide from pitch-blende and its use for the colouring of glass. These were the bases on which Johnson built his business, namely, bullion assaying, the refining of platinum metals, the preparation of pottery and glass colours and the extraction of uranium oxide. And it is noteworthy that in the present business of Johnson, Matthey and Company, these foundations are still distinguishable in the bullion, platinum, ceramic and rare metal sections of the business.

With the growth of his business, Percival found it necessary to travel considerably and a visit he made to Germany turned out to be of considerable importance. As a result of his observations, he adopted the German shaking-washing table for classifying ores and was the first to introduce this particular form of apparatus to this country. His quest for cobalt led him to the famous Blaufarbenwerke at Schneeberg, where other colours were being made besides cobalt blue, and found something of even greater interest to him than the cobalt colours. This was the first European manufacture in quantity of the alloy known as nickel silver. He decided to make use of this knowledge in England and acquainted himself with the details on the spot. As a direct result it is claimed that Johnson was the first man to refine nickel in England.

In connection with gold imports from the Imperial Brazilian Mining Association, formed in the latter part of 1824, the author gives some very interesting information on how the London Bullion Market worked in those days. It was very much a closed corporation; if the gold had to be refined the only recognised refinery was at the Royal Mint. From the beginning of the Association's operations until 1832, the gold brought to London was in the form of crudely melted bars, coarse in appearance, discoloured and brittle through the presence of iron, palladium and tellurium. All brittle gold had to be toughened before it was accepted by the Royal Mint and this had to be done by the Bank's melters who used the barbarous method of adding corrosive sublimate, a ladle full of which was placed on the melted gold; it was then stirred, much of the base metal disappearing with the volatilised mercury and doubtless some of the gold too. Later it was found that Johnson had discovered a method of separating from gold dust all metals in combination with it, and which consisted of silver, platina, palladium, rhodium and iridium. Arrangements were made with Johnson to treat the gold dust, and the quantity of material he was called upon to deal with was very considerable, at first running in the neighbourhood of 50,000 ounces of gold per year. This placed a heavy burden on the refining capacity at Hatton Garden and a new refinery was built in 1835.

By this time Johnson was not only interested in assaying, but directly connected with several mining ventures in England, as a shareholder and in several cases as a director. Thus he combined his scientific knowledge with business and had an active hand in the majority of these ventures, sometimes as managing director and sometimes as consultant.

For some time Johnson had been on the look out for young blood to come into his business and succeed him in its management. He had been very friendly for several years with a wealthy stockbroker named John Matthey who had two sons, George and Edward, and in 1838 an arrangement between him and Johnson was made for these boys to be apprenticed to the firm. There was

a financial arrangement as a consideration. This, coupled with an earlier understanding with Captain Sellon that he also should have the right to nominate two sons to enter the firm, provided for the continuance of Johnson's business, and as the story unfolds it is shown how fortunate he was in his choice.

In September, 1851, Johnson took George Matthey into full partnership, the title of the firm becoming Johnson and Matthey. Late in 1857 a further important agreement was made which set up the future structure of the business. Johnson and George Matthey were to remain partners until March, 1860, when Johnson was to retire and George Matthey, John Sellon and Edward Matthey were to become partners in the business for 21 years.

As the author states, Johnson's chief monument to-day is the London business of which he so well laid the foundations, which are still visible in the business structure of Messrs. Johnson, Matthey and Co. Ltd., eighty years after his death. The branches that he started consisted of assaying, carrying with it the ideas of quality and precision, of platinum, of the vitreous colours and of the production of compounds of the rare metals represented by uranium. These branches still cover the major sections of the business of the Company to-day. Extensions have been great but nearly all are strongly related to the original from which they spread. The Company's treatment of its workpeople has remained throughout that which Johnson would have wished to continue. The business has been developed and strengthened by the continuous ploughing back of a major part of the profits that it has earned, and after more than a hundred and thirty years it still goes steadily on, bigger in scope, but preserving a character that its founder could still approve.

There is much to learn from this story of Percival Johnson and the author has presented it so admirably that the many who will read it, particularly the younger readers, will be grateful to him for his efforts to record the activities of one of the greatest of Britain's metallurgical pioneers.

Trade Publications

We have received from The Brockhouse Organisation a very useful little booklet whose aim is to provide buyers with a concise account of Brockhouse production scope. The Organisation comprises a number of branches and subsidiary and associated companies whose activities range from caravan chassis to bus and coach bodies, from jigs and gauges to outboard motors, and from cooking stoves to castings and forgings in various alloys. The booklet contains not only a guide to the products already made and marketed by Brockhouse Companies, it also refers to production capacity in certain engineering processes, and to contract work which could be undertaken.

An entirely new edition of the Birmal Data Book is now available from Birmingham Aluminium Casting (1903) Co. Ltd., Dartmouth Road, Smethwick, 40, Birmingham. The information contained in this booklet has been drawn up with the idea of giving potential users of light alloy castings and zinc alloy pressure die castings, the essential particulars of the properties of the alloys in general use. While this information will help the designer and production engineers to specify suitable alloys, the advantage of consultation with the foundry before proceeding too far with the design, cannot be too strongly urged. This recommendation is made because the choice of a suitable alloy may greatly influence the ultimate economy in production. Each alloy is treated separately and related specifications are clearly indicated both within the text and in comprehensive indexes.

A new technical circular has been issued by The Quasi-Arc Co., Ltd., Bilston, Staffordshire, describing their Low Hydrogen 35 electrode which has been designed to provide an ultimate tensile strength of at least 35 tons/sq. in. in the weld metal. These electrodes are classified according to B.S. 1719 : 1951, with the coding E. 616 (corresponding to the American Welding Society coding E. 7016). The hydrogen content of the weld metal deposited by the various sizes of electrode is 0·5–1·5 ml. per 100 g. of metal deposited, thus being well below the requirements of the American Welding Society specification which permits up to 10 ml./100 g.

Air Control Installations, Ltd., Ruislip, Middlesex, have recently issued Publication B. 522, which deals with the Cycoil Oil Bath Air Cleaner. The dust-laden air, in passing through, picks up an unusually large volume of oil, with which it is thoroughly mixed in a vortex. Most of the oil picked up is then thrown out by centrifugal action, carrying with it over 90% of the total dust content of the air. The remaining dust, plus a small amount of oil, passes to a filter cell, where it also is removed.

For more than 50 years, Edgar Vaughan & Co., Ltd., Birmingham, 4, have been associated with the metal working industry, and during that period have been responsible for a number of developments relating to the use of oils in that industry. A recent publication deals with the service and products of the Company under such headings as cutting oils, drawing compounds, hydraulic oils, rust preventatives, industrial cleaners, lubricants, and leather packings. The list of products is not complete in that it has been found impracticable to include details of quenching and tempering oils, heat treatment salts, and solid carburisers which are dealt with in other booklets.

Books Received

"Non-ferrous Physical Metallurgy," by Robert J. Raudebaugh. 345 pp., inc. indices. London, 1952. Sir Isaac Pitman & Sons, Ltd. 40s. net.

"Metallurgy for Engineers,— Casting, Welding and Working," by John Wulff, Howard F. Taylor and Amos J. Shaler. 624 pp., inc. index, tables and numerous illustrations. New York and London, 1952. John Wiley & Sons, Inc., and Chapman & Hall, Ltd. 54s. net.

"Strength of Materials," by Arthur Morley, O.B.E., D.Sc., Hon. M.I.Mech.E. Tenth Edition. 583 pp., inc., index, 265 diagrams and numerous examples. London, 1952. Longmans, Green & Co., Ltd. 25s. net.

"Metallurgical Equilibrium Diagrams," by W. Hume-Rothery, O.B.E., F.Inst.P., F.R.S., J. W. Christian, M.A., D.Phil., A.Inst.P., and W. B. Pearson, M.A., D.Phil. 311 pp., inc. index and numerous illustrations. London, 1952. The Institute of Physics. 50s.

NOVEMBER, 1952 Vol. XLVI, No. 277

The Polarographic Determination of Nickel in Aluminium Alloys

By E. C. Mills, A.R.I.C. and S. E. Hermon

Research and Development Division, High Duty Alloys, Ltd., Slough

After initial solution of the sample, and removal of copper and silicon if necessary, the nickel is separated from the aluminium by sodium hydroxide precipitation and subsequently converted to nickel chloride. A polarogram of the nickel is then recorded in pyridine-pyridinium chloride base electrolyte using gelatin as maximum suppressor.

IN High Duty Alloys' laboratory, the accurate determination of nickel in aluminium alloys has always been carried out by first removing the silicon and copper, then separating the nickel as the dimethylglyoxime complex and subsequent cyanometric determination. For small percentages, both weighing the complex and its photometric determination, have also been used to a limited extent. In the presence of cobalt, it is advisable to modify the first method to prevent losses of nickel, and, particularly when relatively large amounts of iron and cobalt are present, cobalt may be found in the final solution and must be removed[1,2].

In view of the above, the possibility of using a polarographic technique as an alternative independent check method was considered. It was hoped to develop a method which would cover the determination of nickel in most types of aluminium alloy, including special and experimental types containing combinations of normal and less common elements which might contain reasonable amounts of cobalt, zinc, tin, etc. It was particularly desired to cover a nickel range in normal alloys from 0·02 to 0·5%.

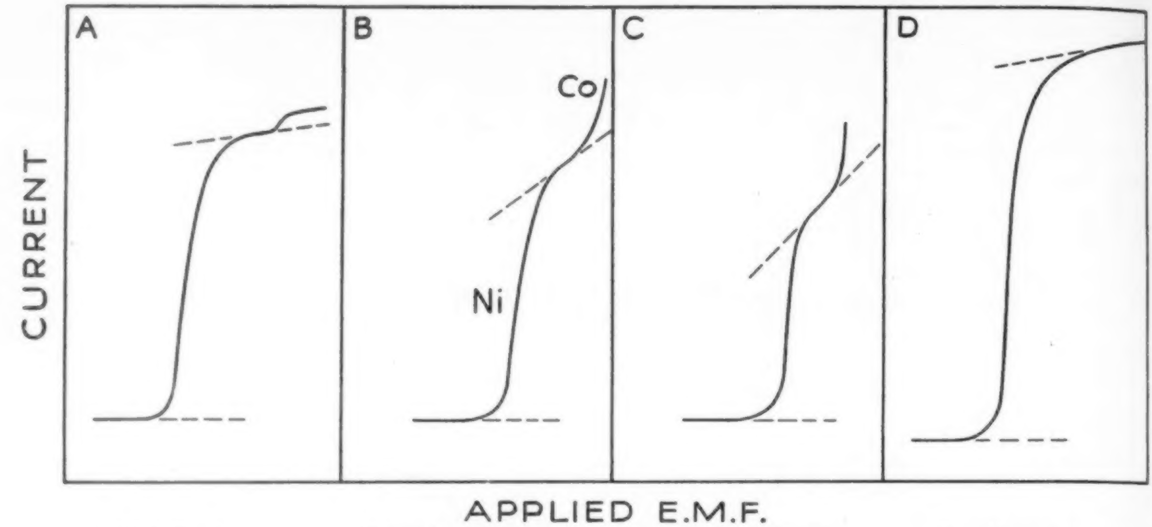
Nickel and cobalt give waves (Ni : $E_{\frac{1}{2}}$ approx. = $-1{\cdot}0$ V. S.C.E. ; and Co : $E_{\frac{1}{2}}$ approx. = $-1{\cdot}3$ V. S.C.E.) in ammoniacal ammonium chloride solution and under certain conditions, the former having been applied to the determinations of nickel in pure aluminium and secondary aluminium alloys[3,4]. With certain ranges of cobalt and nickel, however, we have experienced some difficulty in resolving the respective waves. Pyridine-pyridinium chloride base electrolytes have also been used for the simultaneous determinations of nickel and cobalt, since well defined and easily distinguishable waves are given with this base electrolyte. In a solution containing 0·1M pyridine and 0·1M pyridinium chloride, the half-wave potentials, versus S.C.E., for nickel and cobalt are $-0{\cdot}78$ V. and $-1{\cdot}07$ V. respectively. This type of electrolyte has been used for the determination of nickel in steels[5] and is described in general terms by Kolthoff and Matsuyama[6] for the determination of nickel in aluminium alloys. In the methods quoted, these authors make considerable use of complexing agents to reduce the interfering effects of aluminium and zinc. In our experience, whereas the technique of complexing has been found satisfactory for the analytical control of selected alloys, where more accurate analysis is required and speed is not essential, we prefer the complete separation of the interfering elements, particularly where unusual elements or alloy compositions are encountered and where concentration of the element to be determined is desired. Kolthoff and Matsuyama state that, because of the peculiarities encountered in complexing the various elements, it is necessary to use solutions of the metals containing aluminium at the approximate concentrations present in the alloy solutions for comparison. For convenience and reliability, and particularly with unusual alloys, we prefer, where possible, to use an independent evaluation by direct reference to a standard solution of the element, instead of, or in addition to, the use of standard alloys or processed synthetic solutions.

Study of the Nickel Wave Form

Preliminary tests showed that when tartaric acid was used to complex aluminium from 1g. samples of various alloys, some interference with the nickel waves was observed. Therefore, the separation of the aluminium and other similar elements by sodium hydroxide, was preferred. It was found advantageous to separate zinc along with the aluminium, especially with high zinc alloys such as Hiduminium RR.77,* as the presence of this element in the base electrolyte solution (pyridine-pyridinium chloride) gives a steep upper plateau to the nickel wave.

1 H. Kirtchaick, *Ind. Eng. Chem.* (*Anal. Ed.*), **19**, 95, 1947.
2 B. S. Evans, *Analyst*, **68**, 67, 1943.
3 B. A. Scott, *Analyst*, **73**, 613, 1948.
4 "Analysis of Aluminium and its Alloys"—The British Aluminium Co. (1946), p. 80.

* "Hiduminium" and "RR" are Registered Trade Marks.
5 "Polarography," I. M. Kolthoff and J. J. Lingane, p. 334.
6 Kolthoff and Matsuyama, *Ind. Eng. Chem.* (*Anal. Ed.*), **17**, 615, 1945.



B.C.S. Dural
Ni: 1·84%
Sensitivity: 1/150

Hiduminium RR. 58+Co
Ni: 1·22%
Sensitivity: 1/100

Hiduminium RR. 77
Ni: 0·035%
Sensitivity: 1/5

Pure Aluminium
Ni: 0·15%
Sensitivity: 1/10

Fig. 1—Typical polarograms

A study of the nickel wave form in the pyridine-pyridinium chloride solution was made and a summary of this work is given below. Each experiment was carried out in a total volume of 50 ml., which, in addition to the varying quantities of hydrochloric acid, pyridine and gelatin, contained 5 ml. aliquots of standard nickel chloride solution (the equivalent of 0·5% nickel on a 1g. sample weight).

Variation of pyridine : In solutions containing 2·0 ml. of 0·5% w/v gelatin and 5·0 ml. of 20% v/v hydrochloric acid (S.G. 1·18), additions of between 5 and 12 ml. of 25% pyridine, gave undistorted wave forms. The nickel waves diminished in height as the pyridine concentration increased.

Variation of hydrochloric acid : In solutions containing 10 ml. of 25% pyridine solution and 2 ml. of gelatin solution, additions of 2·5 to 10 ml. of 20% v/v hydrochloric acid gave reasonable waves, which decreased in height with increasing acid concentration, whilst below the lowest addition, distortion occurred.

Variation of gelatin : In solutions containing 5 ml. of the hydrochloric acid solution and 10 ml. of the pyridine solution, the gelatin additions were varied between 1 and 10 ml. of the 0·5% solution. Increase in gelatin concentration was accompanied by a slight decrease in wave height and curving of the top plateaux. With less than 1 ml. of gelatin solution there was incomplete suppression of the maximum.

Stability : The solutions were found to be stable for at least two hours.

The following solution composition was therefore thought to be suitable :—

Total Volume	50 ml.
Pyridine	9–10 ml. of 25% solution.
Hydrochloric Acid	3·75–5 ml. of 20% solution.
Gelatin	approximately 2 ml. of 0·5% solution.

These conditions were then tested over the range 0·02 to 2·0% nickel.

It was noticed that the factors obtained for the percentage of nickel which is represented by unit height division and referred to a common sensitivity, e.g. 1/10, decreased slightly from the lower concentrations up to 0·1%, due to the decreasing slope of the top plateaux.

e.g. 0·02% nickel 1 div. = 0·00253g. nickel.
0·10% nickel 1 div. = 0·00231g. nickel.

Interfering Elements

The presence of *cobalt* steepens the top plateaux, but the nickel polarograms are relatively easy to evaluate, more so than when the amines are used as supporting electrolytes. (See Fig. 1 polarogram B). Increasing the cobalt concentration is accompanied by a progressive slight decrease in wave height.

If *iron* is not completely separated from the solution after precipitation by the pyridine, and is allowed to pass into the solution as a finely divided precipitate or colloidal solution, the nickel wave exhibits a pronounced "hump." Centrifuging appeared to be one of the most efficient ways of removing the precipitated hydroxides.

The interference of the common elements, including *lead, tin and antimony*, normally encountered in aluminium alloys, was found to be insignificant. *Zinc* can cause a significant alteration in wave height, but in practice, considerably less than 0·5% of this element normally remains in the nickel solution after the sodium hydroxide separation, so errors from this source are negligible. (Fig. 1—polarogram C). *Cadmium* causes a slight upward slope in the bottom nickel plateau due to the preceding cadmium wave ; there being no significant effect, however, up to 0·3%. *Chromium* causes a pronounced "rounding" of the upper portion of the nickel wave, without making any significant alteration to the wave height, but, in any case, most of the chromium present in aluminium alloys is eliminated as soluble sodium chromate. It would be necessary to

remove *copper* if present to the extent of more than 0·25%, as this element gives a wave preceding that of nickel, and unless the former is removed, interference with the nickel wave results.

Application to Alloys

The main difficulty encountered was at the sodium hydroxide stage (see the final method), particularly with regard to the elimination of the oxidising agent used to dissolve the precipitate and the adjustment of the final acidity. The following solvent mixtures were tried out for dissolving the hydroxide precipitates. Hydrochloric acid was used with additions of

(1) Nitric acid.
(2) Sodium chlorate.
(3) Hydrogen peroxide.
(4) Nitric acid + hydrogen peroxide.
(5) Nitric acid + sodium nitrite.
(6) Nitric acid + bromine water.

Hydrogen peroxide was found to be the most satisfactory oxidising agent, excess of which was removed by evaporation to dryness. In order to control the acidity of the subsequent solution, the salts were extracted with a known amount of acid.

For *standardisation* purposes, the direct addition of nickel solutions to the base electrolyte solution gave satisfactory agreement with actual alloys processed throughout the method, or with nickel solutions added to the alloys initially or after complete processing to the final stages. It is found necessary to add cobalt solution to the standards in approximately the same percentage as present in the alloys.

Slight difficulty was encountered with some alloys of high iron content, e.g. Hiduminium RR. 58 (1·0–1·7% Fe), due to the presence of a small amount of iron precipitate in the final solution after centrifuging. This was overcome by decantation of the centrifuged solution through a fine grade filter paper.

In the presence of large amounts of lead, and sometimes manganese, a small second wave was observed above the nickel wave (see Fig. 1, polarogram A). This did not interfere with evaluation and could, however, be reduced considerably in magnitude by a double evaporation.

In the method evolved it was found necessary to introduce various modifications in procedure for different alloy types as follows :—

(*a*) As no interference is caused by less than 0·2% copper, a direct sodium hydroxide attack is suitable, and may be used for alloys containing up to 7% silicon.

(*b*) With alloys containing greater than 0·2% copper an initial acid attack is used (employing hydrofluoric acid if silicon is greater than 1·5%), followed by the electrolytic removal of copper and subsequent addition of excess sodium hydroxide. With high silicon alloys (13%) containing low copper, this procedure can be used, omitting the electrolysis stage.

(*c*) As an alternative, deposition of copper on aluminium foil may be used where the copper content is greater than 1%.

(*d*) With alloys containing high amounts of tin, the latter is volatilised by the use of bromine-hydrobromic acid mixture in the initial acid solution.

(*e*) With high chromium bearing alloys, excess hydrogen peroxide is added at the sodium hydroxide stage.

The Final Method

Principle :

After initial solution of the sample, and removal of copper and silicon if necessary, the nickel is separated from the aluminium by sodium hydroxide precipitation and subsequently converted to nickel chloride. A polarogram of the nickel is then recorded in pyridine-pyridinium chloride base electrolyte using gelatin as maximum suppressor.

Solutions Required

All reagents should be of "Analytical Reagent" quality and solutions should be freshly prepared where necessary.

Sodium Hydroxide : Solid and 1% w/v solution.
Hydrogen Peroxide : 20 volume.
Sulphuric Acid : 50% v/v (S.G. 1·84).
Nitric Acid : 50% v/v (S.G. 1·42).
Hydrofluoric Acid : 40% w/v.
Bromine-Hydrobromic Acid Mixture : 1 vol. of liquid bromine, and 9 vols. hydrobromic acid.
Hydrochloric Acid-Hydrogen Peroxide Mixture : 10 vols. of hydrochloric acid (S.G. 1·18), 10 vols. hydrogen peroxide (20 vols.), and 80 vols. of water.
Dilute Hydrochloric Acid : 10% v/v.
Diluted Pyridine Solution : 25% v/v pure. (Approx. 3·2 M).
Gelatin Solution : 0·5% w/v edible gelatin.
Standard Nickel Solution : Dissolve 1·000g. of pure nickel in hydrochloric acid plus a few drops of nitric acid, just evaporate to dryness, extract with 10 ml. of water plus 3 drops of hydrochloric acid and evaporate just to dryness again. Cool, add 2·0 ml. of 10% v/v hydrochloric acid, extract with water and dilute to 1 litre.

1 ml. = 0·0010g. Ni. ≡ 0·10% Ni.

Standard Cobalt Solution : Process 1·000g. of pure cobalt as for the nickel solution omitting the addition of nitric acid.

1 ml. = 0·0010g. Co. ≡ 0·10% Co.

Procedure

Initial Solution of the Alloy and Preliminary Treatment.

Weigh out a 1·00g. sample into a suitable beaker, cover and proceed as in the selected method given below :—

(*a*) *Alloys containing less than 0·2% Copper and less than 3% Silicon.*

Add 5g. of sodium hydroxide pellets and 30 ml. of hot water. (For 3–7% silicon alloys make a dropwise addition of boiling water). When the reaction is complete add 5 ml. of hydrogen peroxide and boil for 2–3 minutes. Dilute to 150 ml. with hot water, and boil for 2–3 minutes. Allow the precipitate to coagulate and proceed with filtration as noted later.

(*b*) *Alloys containing greater than 0·2% Copper and less than 1·5% Silicon.* (Also alloys containing less than 0·2% copper and less than 1·5% silicon, omitting the copper separation stage).

Add 9 ml. of 50% v/v sulphuric acid and 20–30 ml. of 50% v/v nitric acid and digest on the hot plate until solution is complete. Raise the cover glass on a glass hook, and evaporate the solution just to fumes. Cool, wash down the cover, hook and beaker walls, dilute to 70–80 ml., add 3·0 ml. of 50% v/v nitric acid and heat

until all the salts are in solution. Dilute to 150 ml. with cold water and remove the copper by electrolysis at 4 amps. for 20–30 minutes using platinum gauze electrodes and stirring. Remove the electrolyte, after washing down the electrodes and stirrer (with the current still switched on) with hot water, cover the beaker with a watch glass and carefully add 16g. of sodium hydroxide pellets. Agitate the solution *gently* until all the pellets have dissolved and the aluminium hydroxide precipitate has all redissolved. Cautiously add 5 ml. of hydrogen peroxide and heat to boiling (about 200 ml. bulk). Boil for 1–2 minutes, allow precipitate to coagulate and filter as noted later.

(*c*) *Alloys containing greater than* 1% *Copper: Separation by means of Aluminium Foil.*

Dissolve as in (*b*) and (*d*). Fume for 5 minutes, cool, dilute to about 80 ml., add 8 ml. of 50% v/v sulphuric acid and boil until all the sulphates are in solution. Adjust the bulk of the solution to 80 ml., add a strip (3 in. × 1 in.) of pure aluminium foil, cover the beaker and keep the solution just below its boiling point for 20–30 minutes. (Make up to 80 ml. with water as required and shake occasionally.) Filter off the copper and aluminium foil on a Greens 81F 12·5 cm. filter paper, collect the filtrate in a 300 ml. conical beaker and wash out the original beaker. Also wash the filter paper and residue with hot water until the filtrate reaches a bulk of 150–200 ml. Cover with a watch glass, *carefully* add 21g. of sodium hydroxide pellets and complete as in (*b*).

(*d*) *Alloys containing greater than* 0·2% *Copper and greater than* 1·5% *Silicon.* (Also alloys containing less than 0·2% copper and greater than 1·5% silicon omitting the copper separation stage.)

Dissolve the sample as in (*b*). When solution is complete, remove the cover glass, add sufficient hydrofluoric acid to remove the silicon, dilute to 60 ml. evaporate carefully to a pasty condition, dilute to 30–40 ml. and evaporate *carefully* to fumes. Fume 5–10 minutes. Dilute and proceed as in (*b*) or (*c*) above.

Special Alloys

(*e*) *Alloys containing Large Amounts of Chromium.* Use an acid attack method, i.e. (*b*) and add plenty of hydrogen peroxide at the sodium hydroxide precipitation stage to ensure conversion of the chromium to sodium chromate.

(*f*) *Alloys containing Large Amounts of Tin.*

Dissolve the sample in 9 ml. of 50% v/v sulphuric acid and 30 ml. of bromine-hydrobromic acid mixture. Evaporate to fumes, cool, add a further 20 ml. of bromine-hydrobromic acid mixture, re-evaporate to fumes and fume for 10 minutes. Remove the copper as in (*b*) or (*c*).

Treatment of the Hydroxide Precipitate and Polarographic Measurement.

Filter the precipitate on a Greens 81F, 12·5 cm. Hyduro filter paper using a short-stem funnel, wash out the beaker with hot 1% sodium hydroxide solution and wash the precipitate 4 times with same solution. Wash out the beaker and wash the paper and precipitate once with hot water. Transfer the funnel to the original beaker (the beaker in which precipitation was made), pierce the paper and wash through the precipitate with hot water. Dissolve off the last traces of the hydroxides with two 10–12 ml. portions of hot hydrochloric acid-hydrogen peroxide acid mixture and wash the paper well with hot water. Evaporate to dryness, and wash round.

TABLE I.—TYPICAL RESULTS OF THE METHOD.

Sample Identification	Alloy Type	Polarographic %	Standard %
S. 207	Hiduminium 66	0·053	0·046
SP. 489	Hiduminium 90	0·056	0·053
SP. 510	L. 33	0·083	0·082
SP. 502	Hiduminium 20	0·102	0·105
B.C.S. 216	Dural	0·213–0·226*	0·22
SP. 496	Hiduminium 40	0·34	0·35
SP. 485	Hiduminium 55	0·41	0·42
SP. 460	Hiduminium RR. 50	0·73	0·74
S. 1078	EXP. 289	1·01	1·02
SP. 494	Hiduminium RR. 58	1·34	1·31
SP. 495	Hiduminium RR. 58	1·68	1·67
B.C.S. A	Dural	1·84	1·85
S. 1090	Hiduminium Y	1·99	1·97
S. 488	Special alloys containing 1·05% Co	1·19	1·22
S. 488 + Mn		1·20	1·22
S. 868	Special alloys containing 0·25% Co	0·90	0·89
S. 1077		1·05	1·05

*Seven Results.

Re-evaporate the solution just to dryness, extract the residue with 7·50 ml. of 10% w/v hydrochloric acid and an equal volume of water, warming if necessary. Transfer the solution to a 50 ml. graduated flask, containing 9·0 ml. of 25% v/v pyridine solution and wash out the beaker with water until the graduation mark in the flask is reached. Mix well, stand a few minutes and then centrifuge* a suitable amount of the solution. Transfer 10·0 ml. to a 10·0 ml. graduated flask, add 0·5 ml. of 0·5% w/v gelatin solution and mix well.

Bubble with nitrogen for a few minutes. Measure on the polarograph† at adequate sensitivity over an applied potential range of −0·5 to −1·3 volts (or −0·5 to −1·1 volts if *cobalt* is present), with maximum damping (setting 10) and if desired also with a small amount of counter current (setting 3).

Typical sensitivities :

0·1%	1/7
0·2%	1/15
0·4%	1/30
1·0%	1/70
2·0%	1/150

Standards :

Three procedures can be used :—

(1) Take an appropriate aliquot of nickel solution, add 9·0 ml. of 25% v/v pyridine solution, 7·5 ml. of 10% v/v hydrochloric acid, dilute to 50 ml., add 2·5 ml. of 0·5% w/v gelatin solution, mix and record the polarogram.

(2) Process two samples of similar type and composition of known nickel content, with the samples.

(3) Process two samples of a similar type of low nickel content and to one make a suitable addition of nickel solution.

If *cobalt* is present, use an alloy sample of similar cobalt content or add a suitable aliquot of cobalt solution to the standard.

Alloys Tested and Typical Results

Nickel has been satisfactorily determined in a large variety of Hiduminium and special alloys which contain, in addition to copper, magnesium, iron, silicon, titanium, manganese, zinc and cobalt, one or more of the following elements.

* Filtration on a fine grade filter paper can be used for most alloys.
† Cambridge Polarograph for Micro-Analysis. List No. 109A.

Continued on page 266

Correspondence: Precise Measurement of Fatigue Test Load

The Editor, METALLURGIA.
Sir,

Our attention has been drawn to an article in METALLURGIA for August, 1952, on the "Precise Measurement of Fatigue Test Load" by M. H. Roberts, B.Sc., Brown–Firth Research Laboratories, Sheffield, in which he states that the lack of precision of the optical lever method of measuring the alternating tension and compression in push-pull fatigue tests led to the development of an electrical resistance strain gauge method, the article detailing the method adopted.

We, the makers of the Haigh Alternating Stress Testing Machine, are perturbed at the criticisms contained in this article. These criticisms might have been considerably modified had the writer first communicated with us, and had he paid as much attention to the necessary detail in mechanical testing as he has to the electronic method described, there is no doubt whatsoever that he would have obtained all the accuracy required from the mechanical optical method.

To take Mr. Roberts' sources of error :—

(1) The deflection of the full range is of the order of 50 divisions on the camera scale, and with the apparatus at present developed readings to 0·1 mm. can be taken with ease.

(2) Means to prevent bending, superior to those in any other testing machine, are incorporated in the design, and the experimental method adopted in the calibration of the extensometer by the makers, must and does, ensure absence of bending.

(3) The whole response system of the extensometer is known, and its dynamic sensitivity is reliably the same as its static sensitivity. The frequency of resonance of the mirror system is known, and its damping does not have any effect at the operating speed.

If Fig. 21 were plotted more reasonably with ordinate and abscissa of equal length, it would be seen that the curve approaches an ordinary logarithmic curve, which should give approximately uniform percentage accuracy over the whole scale. This shape is not determined by the approach of the armature, as erroneously assumed by the author, but is produced by the instrument designer, and can be altered by him to suit the requirements of the user.

If chattering is found within the rated range, the machine is not in the condition in which it left the maker's works, and such obstructions as must be present in the gaps should be removed, and damage to the pole faces made good. Doubtless the operating conditions for the machine, which are the subject of this criticism, are at fault. The maker will always be pleased to advise the user on any subject relating to the accuracy of the results obtained.

We feel, in our own interests, we must comment on this article, as it may have raised doubts in the minds of present and prospective users, as to the accuracy of the results obtained from our Haigh Alternating Stress Testing Machines.

Yours faithfully,
J. DUNBAR,
Director and Works Manager,
Bruntons (Musselburgh) Ltd.

Musselburgh,
6th October, 1952.

The Editor, METALLURGIA.
Sir,

I welcome the opportunity, afforded by Mr. Dunbar's letter, of discussing further the problem of accurate calibration of fatigue testing machines of the Haigh type. Perhaps in my enthusiasm for the high sensitivity and precision of the new electrical method I tended to exaggerate some of the limitations of the older mechanical method, which Mr. Dunbar defends. Since reading his remarks, I have carried out a very careful comparison of the two methods, by cementing strain gauges to one of the mirror extensometer testpieces so that both methods could be used simultaneously on the same testpiece. This involved the difficulty of fixing gauges to a curved surface, and a slightly greater risk of fatigue failure of the gauges, but judging from the static calibration graph obtained after performing the dynamic test, the gauges behaved satisfactorily.

Regarding the sources of error :—

(1) The deflection obtained for a load of 1·5 tons was just under 40 mm., and the lamp filament image, after carefully cleaning the mirror and lens with lens tissue and adjusting the lens for sharpest focus, was 0·3 mm. wide, ignoring the less brilliant diffuse illumination surrounding the brightest area. It is very difficult to estimate the reading to better than 0·2 mm., and the calibration table supplied by the makers quotes readings to the nearest 0·25 mm. This sensitivity of reading may be deemed adequate at maximum deflection but is less so at half or one-third maximum load.

(2) Messrs. Bruntons are fortunate in being able to ensure complete absence of bending in the static calibration, but the user is not always so fortunate, and it can be difficult for him to obtain a perfect straight line through the origin. Any slight tilt of the whole extensometer, as the load is applied, and the slack taken up, also causes an error. The tables appended hereto show clearly the superiority in such circumstances of the electrical method, which is quite insensitive to such troubles if the two active gauges are exactly opposite each other (which is more difficult to achieve on the round bar of the mirror extensometer than on a square bar). It was not intended to accuse the Haigh machine of introducing appreciable bending, but rather to emphasise the immunity of the electrical method from error due to such a cause.

Two sets of readings were taken in the static calibration, one with a zero check after each load, the other in staircase fashion without intervening zeros. At least two readings for each value of load were taken in each of the two sets, and it will be seen that all the electrical readings show extremely high reproducibility and a very linear calibration but for a slight zero offset, while the optical readings show a much greater variation.

(3) We have one Haigh machine, No. 54, working at 2,000c/min. or 33⅓c/s., and three, Nos. 65, 68 and 70, working at 6,000c/min. or 100c/s. A calibration of machines 54 and 70 was done with the mirror extensometer fitted with strain gauges. If the sensitivity of the extensometer is the same at both 33⅓ and 100c/s., the ratio of resistance change to optical deflection should remain constant. This ratio, in ohms/mm., was worked out for each reading, and also a weighted mean value

TABLE I.—STATIC TESTS.

Load (tons)	Resistance (ohms)	Change	Optical Reading (mm.)	Change
0	70·23		18·7	
0·5	87·74	17·57	28·1	9·15
0	70·11		19·2	
0·5	87·72	17·60	28·7	9·0
0	70·13		20·2	
1·0	104·73	34·62	43·2	22·75
0	70·10		20·7	
1·0	104·72	34·61	44·1	23·4
0	70·11		20·7	
1·5	121·82	51·73	59·8	38·8
0	70·07		21·3	
1·5	121·84	51·76	60·3	38·95
0	70·09		21·4	
0	70·09	0	21·4	0
0·5	87·66	17·57	31·4	10·0
1·0	104·61	34·52	45·8	24·4
1·5	121·82	51·73	60·8	39·4
1·0	104·53	34·44	46·1	24·7
0·5	87·64	17·55	32·2	10·8
0	70·18	0·09	21·7	0·3
0·5	87·66	17·57	31·6	10·2
1·0	104·66	34·57	45·9	24·5
1·5	121·86	51·77	60·9	39·5
1·0	104·59	34·50	46·3	24·9
0·5	87·71	17·62	32·4	11·0
0	70·21	0·12	22·0	0·6

Slope of electrical calibration—65·5 lb./ohm.
Slope of optical calibration—76·5 lb./mm.

worked out for each of the two machines by taking the sum of all the resistance changes and dividing by the sum of all the optical deflections, thus giving proportionately more weight to larger readings. A difference of 7% was found, indicating either a 7% higher sensitivity of the optical method at 100c/s. or a 7% drop in sensitivity of the gauges in going from 33⅓ to 100c/s. This phenomenon does not involve the static or absolute calibration at all. Assuming, as a hypothesis, that the electrical method is accurate, the static calibration suggests that the optical method gives results some 2½% low at 33⅓c/s. and 4½% high at 100c/s. No definite figure of accuracy of load measurement appears to be claimed in Messrs. Bruntons' literature on the Haigh machines.

It would be of interest to know how Messrs. Bruntons compare the static and dynamic sensitivities of the extensometer, and to examine our electrical extensometer by the same method if possible.

TABLE III.—MAKERS' CALIBRATION OF EXTENSOMETERS

Load (lb.)	Divisions Movement on Scale			
	No. 54	No. 65	No. 68	No. 70
250	3·0	2·75	2·75	2·5
500	5·75	5·5	5·25	5·0
750	8·75	8·25	8·00	7·5
1,000	12·0	11·0	10·75	10·0
1,250	14·75	13·75	13·25	12·5
1,500	17·75	16·5	16·00	15·0
1,750	20·75	19·0	18·75	17·75
2,000	23·75	21·75	21·25	20·25
2,250	26·5	24·5	24·00	22·75
2,500	29·5	27·25	26·50	25·25
2,750	32·5	30·0	29·25	27·75
3,000	35·5	32·75	32·0	30·50
3,250	38·5	35·5	34·50	33·0
3,500	41·25	38·25	37·25	35·50
3,660	—	40·0	—	—
3,750	—	—	—	38·0

TABLE IV.—MAKERS' CALIBRATION OF HAIGH MACHINES

Stress Meter Reading	Range of Stress (lb.)			
	No. 54	No. 65	No. 68	No. 70
10	180	60	70	110
20	340	140	160	210
30	470	240	260	310
40	570	340	350	420
50	700	450	450	525
60	850	580	575	625
70	1,030	740	710	760
80	1,200	895	850	925
90	1,420	1,075	1,020	1,100
100	1,630	1,260	1,200	1,280
110	1,910	1,515	1,420	1,530
120	2,200	1,820	1,700	1,850
130	2,510	2,225	2090,	2,260
140	2,980	2,770	2,600	2,840
150	3,490	3,620	3,475	3,700

Plotting the maker's figures for our machines on paper with a logarithmic vertical scale gives a fairly straight line, but for the higher frequency machines its slope does increase somewhat above 120, and still more above 140 on the stress meter, so that the highest reading accuracy is found in the range 90 to 120 on the meter. The chattering referred to took place when two test pieces were connected in tandem, allowing a greater movement than with a single testpiece, which gives no chatter. I must apologise for giving an inaccurate impression on this last point.

TABLE II.—DYNAMIC TESTS.

Machine 70, 6,000c/min.

Stress Meter	Resistance (ohms)		Change (ohms)	Load Range (lb.)	Mirror (mm.)		Difference (mm.)	Load Range (lb.)	Ohms mm.
	Tension	Compression			Tension	Compression			
0	71·28	71·28	0	0	33·8	33·8	0	0	—
30	73·51	68·99	4·52	300	36·0	31·9	4·1	310	1·10
60	75·97	66·46	9·51	620	38·2	29·7	8·5	650	1·12
80	78·13	64·35	13·78	900	40·1	27·7	12·4	950	1·11
90	79·46	62·94	16·52	1,080	41·3	26·6	14·7	1,125	1·12
100	81·20	61·42	19·78	1,300	42·7	24·8	17·9	1,370	1·105
110	83·13	59·52	23·61	1,550	44·2	23·3	20·9	1,600	1·13
120	85·55	57·02	28·53	1,870	46·2	21·0	25·2	1,930	1·13
130	88·70	53·90	34·80	2,280	49·2	17·8	31·4	2,400	1·11
			Total 151·05	9,900			Total 135·1	10,340	Mean 1·118

Mirror result 4·4% above resistance result on average.

Machine 54, 2,000c/min.

Stress Meter	Resistance Tension	Resistance Compression	Change (ohms)	Load Range (lb.)	Mirror Tension	Mirror Compression	Difference (mm.)	Load Range (lb.)	Ohms mm.
0	71·75	71·75	0	0	38·8	38·8	0	0	—
30	75·64	68·12	7·52	490	40·9	34·8	6·1	470	1·23
60	78·89	65·04	13·85	910	43·7	32·2	11·5	880	1·20
80	81·50	62·18	19·32	1,265	45·9	29·8	16·1	1,230	1·20
90	83·48	60·68	22·8	1,490	47·3	28·5	18·8	1,440	1·21
100	85·32	59·42	25·9	1,700	49·0	27·0	22·0	1,680	1·18
110	87·48	57·48	30·0	1,965	50·4	25·7	24·7	1,890	1·21
120	89·45	54·95	34·5	2,260	52·7	23·5	29·2	2,230	1·18
130	92·45	52·75	39·7	2,600	54·9	21·5	33·4	2,560	1·19
140	96·6	48·8	48·8	3,200	58·3	18·4	39·9	3,050	1·20
150	101·4	44·4	57·0	3,730	62·1	14·5	47·6	3,640	1·20
			Total 299·4	19,600			Total 249·3	19,100	Mean 1·200

Mirror result 2½% below resistance result on average.

In writing the article, it was felt that although the possibilities of the subject had not been exhausted, yet the results so far achieved were worth reporting. It is always a good thing to have an alternative method of determining a quantity, and if Messrs. Bruntons, or other users of Haigh machines, would be interested to use our apparatus, or have any observations to offer on the problem, we shall be pleased to give our fullest co-operation.

Yours faithfully,
M. H. ROBERTS,
The Brown–Firth Research Laboratories.

Sheffield.
17th October, 1952.

The Editor, METALLURGIA.

Sir,

I thank you for forwarding Mr. Roberts' reply to our letter of 6th October, and would comment as follows :—

(1) Regarding the sources of error—we now obtain an image of 0·15 mm. and have no difficulty when using a viewing glass on a clear scale, in approximating to 0·1 mm.

(2) The author's claims for the superiority of the electrical method are conditioned by his difficulties with the mechanical method. Bruntons are prepared to give the benefit of their experience in this matter if requested.

(3) Lacking full information of the precautions taken by the author to ensure accurate and satisfactory operation of the optical method, it is not possible to criticise his statement.

It is felt that in the light of this new information, and Mr. Roberts' obviously sincere desire to obtain accurate results, that a full and frank discussion between the parties concerned would remove any misunderstanding.

Yours faithfully,
J. DUNBAR,
Director and Works Manager,
Bruntons (Musselburgh) Ltd.

Musselburgh.
22nd October, 1952.

New and Revised British Standards

GRADUATED PIPETTES AND ONE-MARK CYLINDRICAL PIPETTES. (B.S.700 : 1952). PRICE : 5s.

THIS British Standard was first published in 1937 and amendments were issued in 1945 and 1946. It has now been completely revised and brought up-to-date.

It specifies three types of graduated pipette : Type 1 calibrated for delivery from zero mark to graduation marks, Type 2 calibrated for delivery down to jet, Type 3 calibrated for content, and two types of one-mark cylindrical pipette : Type 1 calibrated for delivery, Type 2 calibrated for content. The sizes specified are 1, 2, 5, 10 and 25 ml. for each type of graduated pipette, 1, 2, 5, 9 and 10 ml. for the Type 1 one-mark pipette and 1 ml. only for the Type 2 one-mark pipette. It gives full dimensions but, in accordance with current practice in British Standards for volumetric glassware, lists only the essential ones as mandatory, the remainder being given for the guidance of manufacturers. It includes standard methods for the determination of capacity and delivery time, and tolerances for both, as well as requirements for material, construction, graduation and marking.

The publication of this revision marks an important stage in the attempt to cover in British Standards the scientific glassware in everyday use in the average laboratory. Standards already published in the series include the following :—

B.S. 572—Interchangeable conical ground glass joints.
B.S. 604—Graduated measuring cylinders.
B.S. 605—Crow receivers.
B.S. 612—Nessler cylinders.
B.S. 733—Density bottles.
B.S. 846—Burettes and bulb burettes.
B.S.1583—One-mark bulb pipettes.
B.S.1739—Filter flasks.
B.S.1751—General purpose glass stopcocks.
B.S.1792—One-mark graduated flasks.
B.S.1848—Glass condensers.

A number of new and revised British Standards are also available for more specialised apparatus, and others are in course of preparation.

METHODS FOR THE ANALYSIS OF IRON AND STEEL.
PART 24. SMALL AMOUNTS OF CHROMIUM IN IRON AND STEEL (ABSORPTIOMETRIC METHOD) (B.S.1121 PART 24 : 1952). PRICE 2s.
PART 25. DETERMINATION OF VANADIUM IN FERRO-VANADIUM (B.S.1121 PART 25 : 1952). PRICE 2s.
PART 26. DETERMINATION OF MOLYBDENUM IN LOW ALLOY STEELS CONTAINING UP TO 0·5% TUNGSTEN (B.S.1121 PART 26 : 1952). PRICE 2s.

THE British Standards Institution has recently published the above mentioned new parts of B.S.1121.

The principle of the method of determining chromium is by solution of the sample in dilute nitric acid, oxidation of the chromium by fuming with perchloric acid and the use of the coloured complex formed with diphenylcarbazide as a measure of the chromium content.

The principle of the method of determining vanadium is by solution of the sample in sulphuric and nitric acids and oxidation of the vanadium to the quinquivalent condition with potassium permanganate. Excess of potassium permanganate is reduced with sodium nitrite, and sulphamic acid is used to destroy the excess of nitrite. The oxidised vanadium is titrated with ferrous ammonium sulphate and potassium dichromate, using barium diphenylamine sulphonate as an indicator.

The principle of the method for determining molybdenum is precipitation of the molybdenum from a hydrochloric acid solution of the sample with alphabenzoinoxime. The precipitate is re-dissolved and molybdenum, after conversion to thiomolybdate, is separated as sulphide from a solution in which the precipitation of tungsten is prevented by the presence of tartrate ions. The sulphide precipitate is ignited and weighed as molybdic oxide.

PERFORMANCE TESTS FOR PROTECTIVE SCHEMES USED IN THE PROTECTION OF LIGHT GAUGE STEEL AND WROUGHT IRON AGAINST CORROSION. (B.S.1391 : 1952). PRICE 5s.

THIS revised British Standard supersedes the previous edition which was issued in provisional form in 1947. The new specification includes not only the A.R.E. salt droplet test, which was the test included in the 1947

edition, but also the new C.R.L. sulphur dioxide test. The A.R.E. test is based on a method of testing with a sea-water spray and was devised at the Armament Research Establishment, Ministry of Supply. The C.R.L. test, which involves exposure to humid sulphur dioxide originated at the Chemical Research Laboratory, Department of Scientific and Industrial Research. Both these tests have been standardised as a result of investigations made by the Methods of Testing (Corrosion) Sub-Committee of the British Iron and Steel Research Association.

The tests are intended to apply mainly to parts used in permanent building construction where a single coat of stoving paint is applied to bare phosphated or metal coated steel. Both tests give reasonable correlation with service performance under outdoor atmospheric conditions but being essentially accelerated corrosion tests they do not reproduce all the factors involved in the natural deterioration of the paint film. The specification deals mainly with tests on small specimens of steel sheet coated with the protective scheme or schemes, but the A.R.E. test can also be used to examine the local soundness of the protective scheme on the fabricated parts themselves without causing irreparable damage. No hard and fast standards of performance have been laid down because, in view of the wide variety of protective schemes and of conditions of exposure in practice, it is better for the users of the specification to choose standards to suit their individual requirements, e.g., by specifying a minimum test duration to the specified degree of breakdown.

REFERENCE TABLES FOR THERMOCOUPLES. (B.S. 1826/7: 1952). PRICE: B.S. 1826, 7s. 6d.; B.S.1827. 6s.

The British Standards Institution has recently published the following British Standards :—

B.S.1826—Reference tables for platinum/rhodium *v* platinum thermocouples.

B.S.1827—Reference tables for nickel/aluminium *v* nickel/chromium thermocouples.

These reference tables are for use in converting thermocouple voltages into the equivalent measured temperatures and in defining the relation between impressed e.m.f. and scale reading for pyrometers which indicate temperature directly. The tables for platinum/rhodium *v* platinum thermocouples are based on the tables formulated by the National Physical Laboratory, which have been the basis of reference in the United Kingdom for many years. The tables for nickel/aluminium *v* nickel/chromium thermocouples are based on the tables formulated by the National Bureau of Standards of America, since no other tables are in common use in the United Kingdom.

The tables specify the e.m.f./temperature relations for the thermocouples in four ways, as follows :—

(*a*) Millivolts : ° C.
(*b*) ° C. : millivolts.
(*c*) Millivolts : ° F.
(*d*) ° F. : millivolts.

Reference tables for copper *v* constantan thermocouples are in preparation and further tables may be issued in due course.

METHODS FOR THE SAMPLING OF FERROUS METALS AND METALLURGICAL MATERIALS FOR ANALYSIS. PART 2. FERRO-ALLOYS (B.S.1837 : 1952). PRICE 2s. 6d.

THIS Standard (Part 1, dealing with iron and steel, was published earlier this year) is intended for use in conjunction with B.S.1121 " Methods for the analysis of iron and steel." Section 1 sets out the general requirements. Section 2 deals with the sampling of ferro-tungsten, ferro-niobium, ferro-molybdenum, ferro-vanadium and ferro-titanium. Section 3 covers the sampling of ferro-chromium, ferro-silicon, ferro-manganese and spiegel. Section 4 gives recommendations for the sampling of bulk deliveries in wagons. The methods are those which have been found most satisfactory in practice. As is the purpose of the methods of analysis specified in the various parts of B.S.1121, the standard is primarily intended for referee purposes and should be considered as a guide to sound sampling procedure rather than as a rigid specification.

Copies of these standards may be obtained from the British Standards Institution, Sales Branch, 24, Victoria Street, London, S.W.1.

The Direct Reading Spectrometer

A JOINT meeting of The Permanent Magnet Association and The Sheffield Metallurgical Association under the Chairmanship of Dr. E. Gregory has been arranged for November 27th, when Dr. Hasler, co-founder and director of the Applied Research Laboratories, Glendale, California, will present a paper on " The Direct Reading Spectrometer," at the Grand Hotel, Sheffield, at 7.30 p.m.

Dr. Hasler is the leading authority on the use of the direct reading spectrometer and in view of the special interest in this subject a cordial invitation is extended to members of national and local societies. The lecture will replace the one which was to be given by Mr. Speight on November 25th, but he has kindly agreed, following Dr. Hasler, to give his observations of the application of the direct reading spectrometer on a recent visit to American steelworks.

W. Edwards' Scottish Establishment

W. EDWARDS AND CO. (LONDON) LTD., announce the opening of a new establishment at 44, West George Street, Glasgow, where they now have facilities for technical sales and service to meet the growing interest in high vacuum applications in Scotland. The Company intend to have a selected range of equipment available at this address for customers' inspection.

Polarographic Determination of Nickel in Aluminium Alloys

Continued from page 262

Tin	up to 6·5%
Lead	„ 1·5%
Antimony	„ 0·3%
Chromium	„ 0·4%
Vanadium	„ 0·05%
Cadmium	„ 0·1%
Bismuth	„ 0·05%
Beryllium	„ 0·05%

Some typical results obtained by the method and compared with standard figures are given in Table I.

Acknowledgment

The authors wish to thank the Directors of Messrs. High Duty Alloys, Ltd., for permission to publish this work.